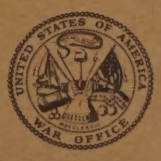
TM 11-5128

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

SUMMATION BRIDGE AN/URM-23

OPERATING, SERVICE, AND OVERHAUL INSTRUCTIONS



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TM 11–5128, Summation Bridge AN/URM–23, Operating, Service, and Overhaul Instructions, is published for the use of all concerned.

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By Order of *Wilber M. Brucker*, Secretary of the Army:

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NG: State AG; units—same as Active Army.
USAR: None.
For explanation of abbreviations used, see SR 320–50–1.

PART ONE

OPERATING INSTRUCTIONS

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SECTION I
GENERAL DESCRIPTION

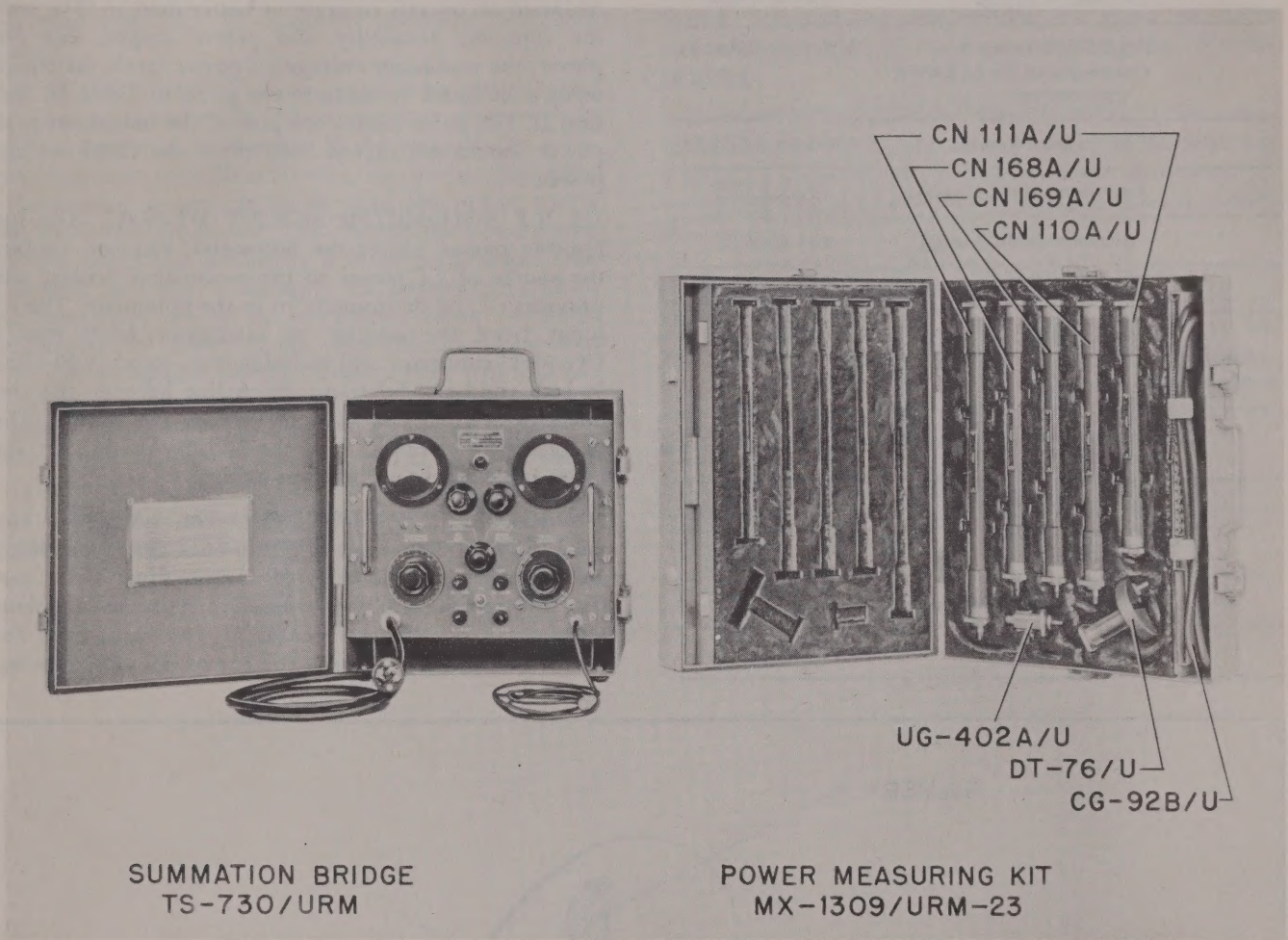

Figure 1-1. Summation Bridge AN/URM-23

1-1. INTRODUCTION.

1-2. IDENTIFICATION. This publication contains operating instructions for Summation Bridge AN/URM-23 (See figure 1-1), manufactured by Bruno-New York Industries Corporation.

1-3. PURPOSE. Summation Bridge AN/URM-23 is a radio-frequency power meter used as an item of test equipment to measure power from 5 milliwatts to 5 watts in the frequency range from 1000 to 4000 megacycles per second. It is designed to operate continuously between —40°C. and +55°C. The power source required is 115 volts ac, 50-1000 cycles per second, with a line current of approximately 0.6 ampere. The equipment is completely self-contained in two cases, the contents of which are listed in Table I.

1-4. DESCRIPTION.

1-5. SUMMATION BRIDGE TS-730/URM. This equipment employs a direct-reading summation type circuit in which a power-sensitive bolometer element acts as one arm of a dc Wheatstone bridge, while at the same time providing the correct resistive termination for r-f (microwave) power entering the power meter. The bridge indicates power directly by measuring the decrease in dc power required to keep the bridge in balance as r-f power is absorbed by the bolometer element. Since at any given operating resistance, the resistance of a bolometer is proportional to the total power dissipated in it, dc power is used to establish the operating resistance of the bolometer and balance the bridge. Then, as r-f power is added to the bolometer,

Table I. Components of Summation Bridge AN/URM-23

Quantity Per Equipment	*Name of Unit*	*Type Designation*
1	Summation Bridge	TS-730/URM
1	Power Measuring Kit (consisting of the following components)	MX-1309/URM-23
1	Combination Case	CY-1405/URM-23
1	Attenuator (3 db, 5 watt)	CN-168A/U
1	Attenuator (6 db, 3 watt)	CN-169A/U
1	Attenuator (10 db, 1 watt)	CN-110A/U
1 (2 section)	Attenuator (20 db, 5 watt)	CN-111A/U
1	R-F Bolometer Mount (with element)	DT-76/U
1	Adapter Connector	UG-402/U
1	R-F Cord	CG-92B/U
5	Bolometer Element (Spare)	—
12	Coupling Screws	AN 501-10-10

dc power is subtracted manually to rebalance the bridge. A dc meter, calibrated in milliwatts, measures this decrease in direct current and indicates the microwave power dissipated in the bolometer. The summation bridge is designed to measure the average value of either c-w or pulse modulated power of frequencies between 1000 and 4000 megacycles per second, and to maintain an overall accuracy of better than $\pm 15\%$ over the complete frequency and power ranges. For c-w power, the maximum average r-f power levels the equipment is designed to measure are given in Table II, Section II. For pulse modulated power, the maximum peak power should not exceed 2000 times the rated average power.

1-6. R-F BOLOMETER MOUNT DT-76/U. The bolometer mount houses the bolometric element, couples the source of r-f power to the summation bridge, and provides r-f and dc connections to the bolometer. The r-f input from the adapter or attenuator feeds into a UG-46/U connector and is designed to match a 50-ohm. 7/8-inch rigid coaxial transmission line between the frequencies of 1000 and 4000 megacycles per second. The dc receptacle connects into the UG-88/U plug on the input cable of the summation bridge.

1-7. BOLOMETER ELEMENT. The bolometer element, figure 1-2, consists of a thin mica disc upon which are deposited two sections of carbon film. These carbon film sections are power-sensitive resistance elements which have nominal resistances of 100 ohms each for a normal operating dc bias current of 35 milliamperes.

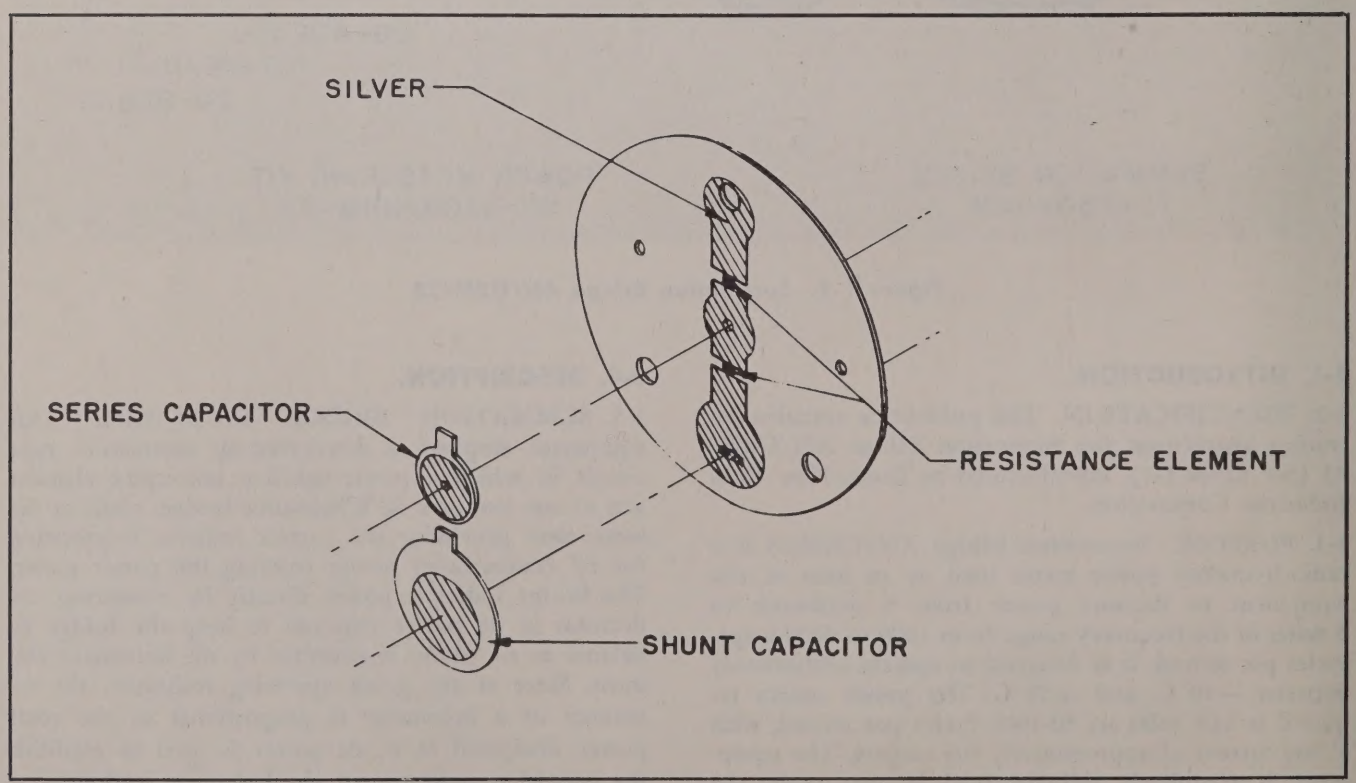

Figure 1-2. Bolometer Element

Two small bypass capacitors are mounted on the mica disc so that the carbon sections are in parallel for incoming r-f signals, giving an r-f impedance of 50 ohms, and in series for dc to form a nominal 200 ohm resistance which acts as one arm of the bridge. The bolometer, in its mount, is designed for an average power range of 5 to 50 milliwatts, a maximum peak power of 100 watts and has a Voltage Standing Wave Ratio of less than 1.30 over the complete operating frequency range.

1-8. ATTENUATORS. Four attenuators are supplied to allow extension of the range of power measurements up to a maximum of 5 watts. If the power to be measured is greater than 50 milliwatts, the proper attenuator is introduced in the circuit between the power source and the bolometer mount. This reduces the power entering the bolometer mount by a fixed percentage. Thus it is only necessary to multiply the power measured by the summation bridge by the correct factor to obtain the original r-f source power. The attenuators supplied with this equipment are fixed coaxial pads which derive their attenuation properties from the use of a metallized resistive coating on an inner conductor of glass. The thickness of the film is small compared with the depth of penetration of the r-f field so that the units exhibit essentially flat attenuation characteristics over the rated frequency range. The meallized inner conductor is housed in a section of standard 7/8-inch rigid transmission line fitted with one UG-45/U and one UG-46/U coupling. The nominal attenuation and power ratings of the attenuators are given in Table I. The VSWR of all attenuators is less than 1.30 over the complete operating frequency range. Calibration data giving the actual attenuation values of the attenuators and deviations from nominal attenuation at three frequencies, and correction factors for ambient temperature are given on cards stowed in a pocket of the case containing the r-f components.

1-9. ADAPTER CONNECTOR UG-402/U. This adapter is supplied to couple the cord CG-92B/U, which is a length of 3/8-inch coaxial cable, to the attenuators or bolometer mount which are designed for 7/8-inch coaxial line.

1-10. CORD CG-92B/U. This cord is a six-foot section of 3/8-inch coaxial cable, for the purpose of coupling r-f power from the source through the adapter to the attenuators or to the bolometer mount. Attenuation values for this cable at three frequencies are stamped on a metal tag attached to the cable. The cable is terminated at each end in a UG-21D/U plug.

1-11. FASTENING SCREWS. Twelve screws are provided for coupling together the flanges on the adapter, attenuators or bolometer mount, as necessary.

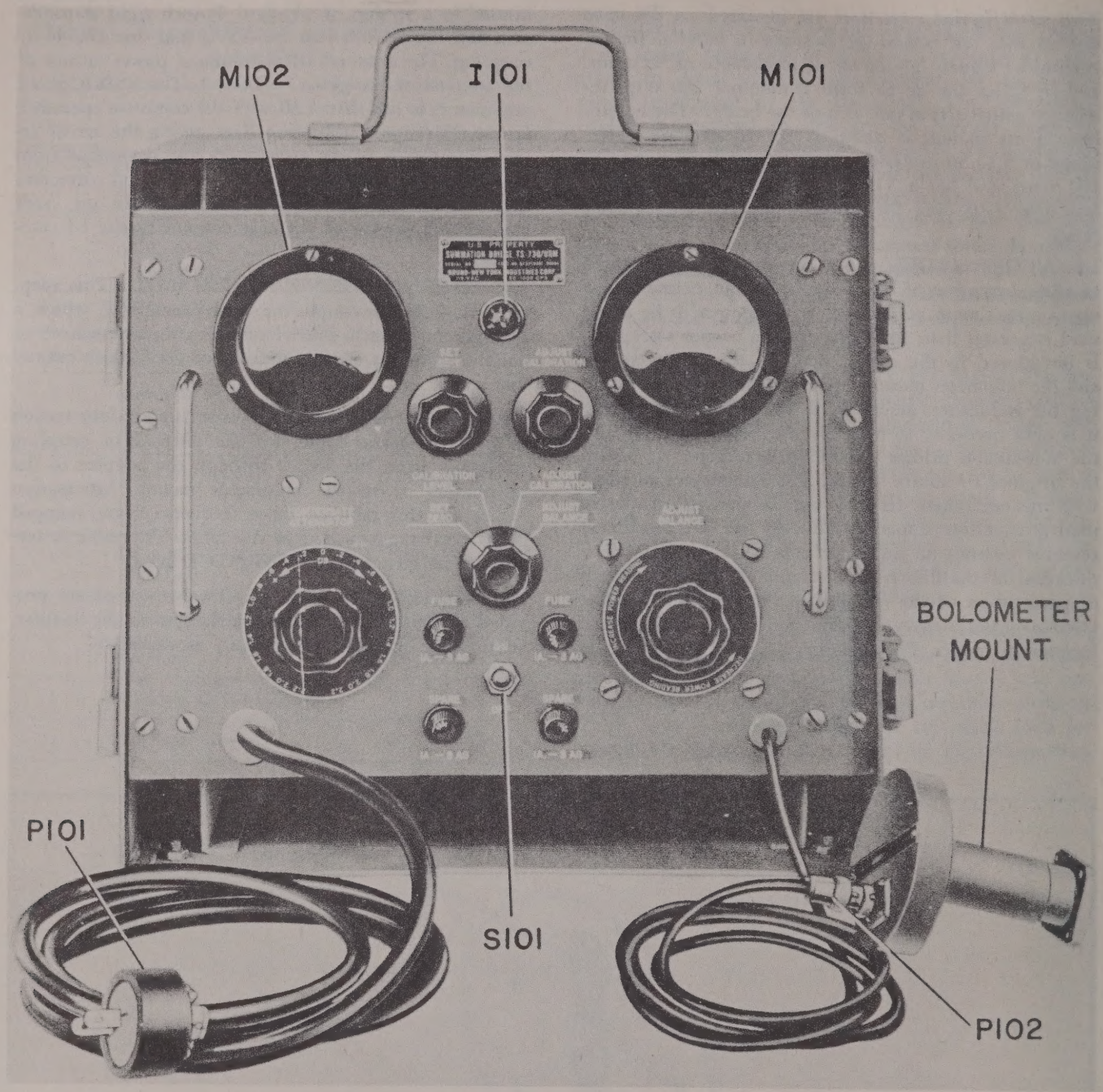

Figure 2-1. Summation Bridge TS-730/URM

SECTION II
OPERATING PROCEDURES

2-1. CONTROLS.

2-2. GENERAL. All controls used in the normal operation of this equipment are located on the front panel of the summation bridge (see figure 2-1). They are discussed in paragraphs 2-3 through 2-8 below.

2-3. "SET ZERO". The "SET ZERO" control, R-148 and R-157, adjusts the initial balance of the bolometer in the bridge circuit. The indication of balance is given by the zero-center galvanometer, M-102, at the upper left of the panel. R-148 is the "Coarse" control while R-157 provides a "Fine" vernier adjustment.

2-4. "ADJUST CALIBRATION". The purpose of the "ADJUST CALIBRATION" control, R-113, is to calibrate the bridge for variations in ambient temperature or individual bolometer and attenuator characteristics and fix the dc bias current necessary to maintain accuracy for each measurement.

2-5. "COMPENSATE ATTENUATOR". Attenuators which are supplied with this equipment will vary from nominal attenuation values because of manufacturing tolerances and frequency and temperature drift. For convenience in calculation, the "COMPENSATE ATTENUATOR" control, S-103, is introduced so that attenuation correction and calibration data may be fed into the bridge calibrating circuit and exactly compensate for the deviations from nominal values. Thus the nominal values may be used to calculate the original source power.

2-6. "ADJUST BALANCE". The "ADJUST BALANCE" control, (R-104, R-107 and R-112), is used, after r-f power has been fed to the bridge circuit, to manually subtract an equivalent amount of dc power and rebalance the galvanometer, M-102. When M-102 is rebalanced, the power meter, M-101, will indicate directly the r-f power applied to the bolometer.

2-7. SELECTOR SWITCH. The selector switch, S-102, has four positions. The first position, "SET ZERO", disconnects the power metering circuit and allows the bridge to be initially balanced by adjusting the "SET ZERO" control. The second position, "CALIBRATION LEVEL", connects the power meter into the circuit to read a calibration value proportional to the dc bias current for the particular bolometer and attenuator used, and the ambient temperature at the time of calibration. The "ADJUST CALIBRATION" position allows the "ADJUST CALIBRATION" control to vary the calibration value of attenuation in the bridge to take into account correction factors required by the attenuator at the particular frequency and temperature used. The fourth position, "ADJUST BALANCE", connects a variable dc attenuator pad into the circuit to allow the dc bias current to be reduced in proportion to the r-f power being measured.

2-8. POWER SWITCH. The "ON-OFF" switch, S-101, at the bottom center of the panel, switches the bridge supply on or off. In the "ON" position, fuses F-101 and F-102 are connected into the line, and the flow of power is indicated by pilot lamp I-101. In the "OFF" position, standby heaters in the unit are energized (so long as the power plug is connected to an ac source) to raise the temperature inside the bridge case in order to deter the effects of humidity and fungus corrosion.

2-9. SEQUENCE OF OPERATION.

2-10. GENERAL. The normal sequence of operation for this equipment is discussed in paragraphs 2-10 through 2-13 below. If the equipment has never been used, or is believed to be in need of repair, the preliminary operation test of Section III should be performed before proceeding with power measurements.

2-11. RATED POWER LEVELS. The maximum average r-f power levels this equipment is designed for are listed in Table II. This maximum source r-f power is determined by the limiting criterion of not more than 50 milliwatts r-f power at the bolometer. For pulse modulated power, the maximum peak power should not exceed 2000 times the average source powers listed.

CAUTION

An attempt should be made to determine in advance the approximate range of power to be measured, and the proper attenuator selected to correspond to the MAXIMUM source power it is anticipated will be encountered. Power levels in excess of the values of Table II may damage the bolometer element or attenuators.

Table II. Rated Power Levels

Attenuator	*R-F Source Power*	*R-F Power at Bolometer*
None	5-50 milliwatts	5-50 milliwatts
3 db	10-100 milliwatts	5-50 milliwatts
6 db	20-200 milliwatts	5-50 milliwatts
10 db	50-500 milliwatts	5-50 milliwatts
20 db	0.5-5 watts	5-50 milliwatts

2-12. CALIBRATION AND POWER MEASUREMENT. Due to variations in calibration for the attenuators and normal fluctuations of bolometric element characteristics and ambient temperature, it is essenial that this equipment be calibrated prior to each use. The calibration and power measurement procedures are as follows

a. Connect bolometer mount to UG-88/U plug on input cable of bridge. Make certain that clamping screws on mount are very tight.

b. Connect adapter and attenuator if required. Use fastening screws located in the r-f components case to couple the flanges together. Tighten screws a small amount at a time consecutively to maintain even pressure at the flanges.

c. Connect power plug to 115 volt ac source. Turn "ON-OFF" switch to "ON". Turn selector switch to "SET ZERO".

d. Allow 20 minute warm-up period.

e. Set "COMPENSATE ATTENUATOR" dial to zero if no attenuator is used. If attenuator is used, refer to proper attenuator calibration card and set dial to algebraic sum of corrections on card for frequency and temperature.

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f. With selector switch in "SET ZERO" position, adjust galvanometer pointer to balance at zero with "SET ZERO" control.

g. Rotate selector switch to "CALIBRATION LEVEL" position. Note reading on non-linear red scale of power meter, M-101.

h. Rotate selector switch to "ADJUST CALIBRATION" position. Vary "ADJUST CALIBRATION" knob until the same value indicated in step (g) appears on the black scale of the power meter. The unit is now calibrated for use.

i. Connect r-f power.

j. Rotate selector switch to "ADJUST BALANCE" position. Vary "ADJUST BALANCE" knob until galvanometer pointer is centered at zero after stabilization. (Do not readjust "SET ZERO" control).

Note

The bolometer element is extremely sensitive to even slight changes in temperature. Since the bolometer is disconnected from its bias current in the "CALIBRATION LEVEL" or "ADJUST CALIBRATION" position of the selector switch, it will cool and change resistance. If the selector switch is left at either of these positions for more than a few seconds, it is recommended that the switch be returned to the "SET ZERO" position and steps (f) through (j) be repeated for maximum accuracy of measurement.

k. Read r-f power on black scale of power meter. With no attenuator in the circuit, the reading obtained corresponds directly to milliwatts of source r-f power. If the 3, 6, 10 or 20 db attenuators are used, the reading must be multiplied by 2, 4, 10 or 100 respectively to obtain milliwatts of source r-f power at the input to the attenuator. If R-F Cord CG-92B/U is used, this power measurement must be further corrected to compensate for the cable attenuation as explained in paragraph 2-13.

2-13. COMPENSATION FOR CORD ATTENUATION. When R-F Cord CG-92B/U is used, the values of r-f power obtained must be multiplied by the following correction factors in order to compensate for the cable attenuation and obtain milliwatts of true source r-f power:

(a) at 1000 megacycles per second, multiply by 1.10

(b) at 2500 megacycles per second, multiply by 1.26

(c) at 4000 megacycles per second, multiply by 1.38

Interpolate multipliers for intermediate frequencies. If desired, the attenuation of the cable may be compensated for in a manner similar to the attenuators by feeding into the "COMPENSATE ATTENUATOR" dial a correction to compensate for both the attenuator and the cable. For example, suppose at the measurement frequency the attenuator calibration card for the 10 db attenuator calls for a compensation of +0.4 db, and that at this frequency the cable attenuation is 1.0 db. The compensation for the cable would be —1.0 db and the total compensation for both cable and attenuator is —0.6 db. This compensation, fed into the "COMPENSATE ATTENUATOR" control, would enable a power measurement to be made and the source r-f power calculated by simply multiplying the reading obtained by 10. This method of compensation can be used only when the algebraic sum of the attenuator and cable compensation factors does not exceed ±2.2 db.

SECTION III

OPERATING CHECKS AND ADJUSTMENTS

3-1. PRELIMINARY OPERATION TEST. Upon initial receipt of the equipment, or after periods of long disuse, a preliminary operation test is necessary. The following procedure will indicate whether the equipment is in proper operating condition:

a. Connect the bolometer mount to the input cable of the Summation Bridge TS-730/URM.

b. Connect the power plug to a 115 volt, 50-1000 cycle per second, ac source.

c. Turn power switch "ON". Pilot lamp should indicate flow of power.

d. Rotate selector switch to "SET ZERO" position. Allow 20 minute warm-up period.

e. Rotate "SET ZERO" control, R-148. Clockwise rotation should move the galvanometer pointer from left to right, counterclockwise rotation from right to left. At normal ambient temperatures of approximately 24°C. (75°F.), zero deflection of the galvanometer should correspond to a setting of the "SET ZERO" control near the middle of its total range of rotation.

f. Balance bridge with "SET ZERO" control, R148, and wait 5 minutes. After this time the bolometer should be stable and there should be no appreciable drift of the galvanometer.

g. Rotate the selector switch to the "CALIBRATION LEVEL" position and then return the selector switch to "SET ZERO". The galvanometer should deflect momentarily and return to balance.

h. Set the selector switch at "CALIBRATION LEVEL". The power meter should deflect, but not the galvanometer. Rotate the "COMPENSATE ATTENU-

ATOR" knob through all positions. The meter reading should be between one-half and full scale and show small, progressively decreasing readings as the control is rotated clockwise.

i. Place the selector switch at the "ADJUST CALIBRATION" position. Rotate the "ADJUST CALIBRATION" knob clockwise. By varying, the "ADJUST CALIBRATION" control it should be possible to obtain on the "Relative Power" scale at least the extreme readings which were obtained in step (h) above.

j. Rotate the selector switch to the "ADJUST BALANCE" position. The galvanometer should now deflect clockwise. Rotate the "ADJUST BALANCE" control fully counterclockwise. The power meter reading and the galvanometer deflection should be reduced almost to zero. If the galvanometer deflection does not return to zero, set selector switch to "SET ZERO" and rebalance galvanometer with "SET ZERO" control. Then reset selector switch to "ADJUST BALANCE" and repeat.

k. Rotate the "ADJUST BALANCE" control clockwise. The galvanometer should deflect clockwise and the meter reading increase to more than full scale.

The equipment is now ready for operation and use.

3-2. CALIBRATION CHECK. Because of the extreme sensitivity to ambient temperature variations, the calibration procedure discussed in Section II is accurate only if the power measurement is made immediately thereafter. If the bridge selector switch is left at any position other than "SET ZERO" for extended periods of time, the switch must be returned to the "SET ZERO" position periodically and the galvanometer balance checked for possible drift. If the pointer is not centered, rebalance the galvanometer with the "SET ZERO" control and repeat the power measurement. This procedure insures maximum accuracy of measurement.

SECTION IV

EMERGENCY OPERATION AND REPAIR

4-1. EMERGENCY OPERATION.

4-2. There is no emergency operation procedure.

4-3. REPAIR.

4-4. GENERAL. The summation bridge is a highly precise item of test equipment and must be kept in good condition to function properly. If the operational test of Section III indicates any malfunction, some elementary maintenance and repair is discussed in paragraphs 4-5 and 4-6 below. For more detailed maintenance information refer to the associated Handbooks of Service and Overhaul Instructions, T.O. 33A1-7-6-2 and T. O. 33A1-7-6-3 respectively, and Parts Breakdown, T.O. 33A1-7-6-4. To insure proper functioning of the equipment, replace all defective parts by exact equivalents both in value and tolerance.

4-5. SUMMATION BRIDGE TS-730/URM. The maintenance on the summation bridge which the operator will normally be expected to perform would consist of the replacement of fuses and pilot lamp. There are two type 3AG, 1-ampere, "Slow-blow" fuses accessible at the front panel, and two equipment spares are located below the active fuses. The pilot lamp, I-101, is a NE-51, 115 volt, neon type and is accessible at the front panel by unscrewing the plastic cap over the lamp. Normally, the replacement of tubes in the bridge necessitates recalibration as discussed in Section V of the Service Instructions Handbook, T.O. 33A1-7-6-2, but in an emergency the recalibration may be omitted. To replace tubes, unfasten the two outside rows of screws which connect the panel to the case and lift out the bridge unit. Remove the right-hand side plate to identify tubes. The tube complement of the bridge is given in Table III.

4-6. BOLOMETER ELEMENT REPLACEMENT. If the bolometer element is burned out due to application of excessive r-f power, the procedure for replacing the defective element with one of the five equipment spares is as follows (see figure 4-1):

Table III. Tube Complement

Reference Symbol	*JAN Type*	*Function*
V-101	5Y3WGTA	Rectifier, power supply
V-102	6080	Series regulating tube
V-103	6AU6WA	Regulating control tube
V-104	5651	Voltage reference base
V-105	5651	Voltage stabilizer

a. Remove the three clamping screws, H-155, holding the two halves of the bolometer mount together.

b. Remove the mounting screw, H-151, and washer, H-152, holding the bolometer element, RT-106, to the center conductor of Z-106.

c. Carefully lift an edge of the bolometer element and remove it from the mount.

d. Remove the spare bolometer element from its

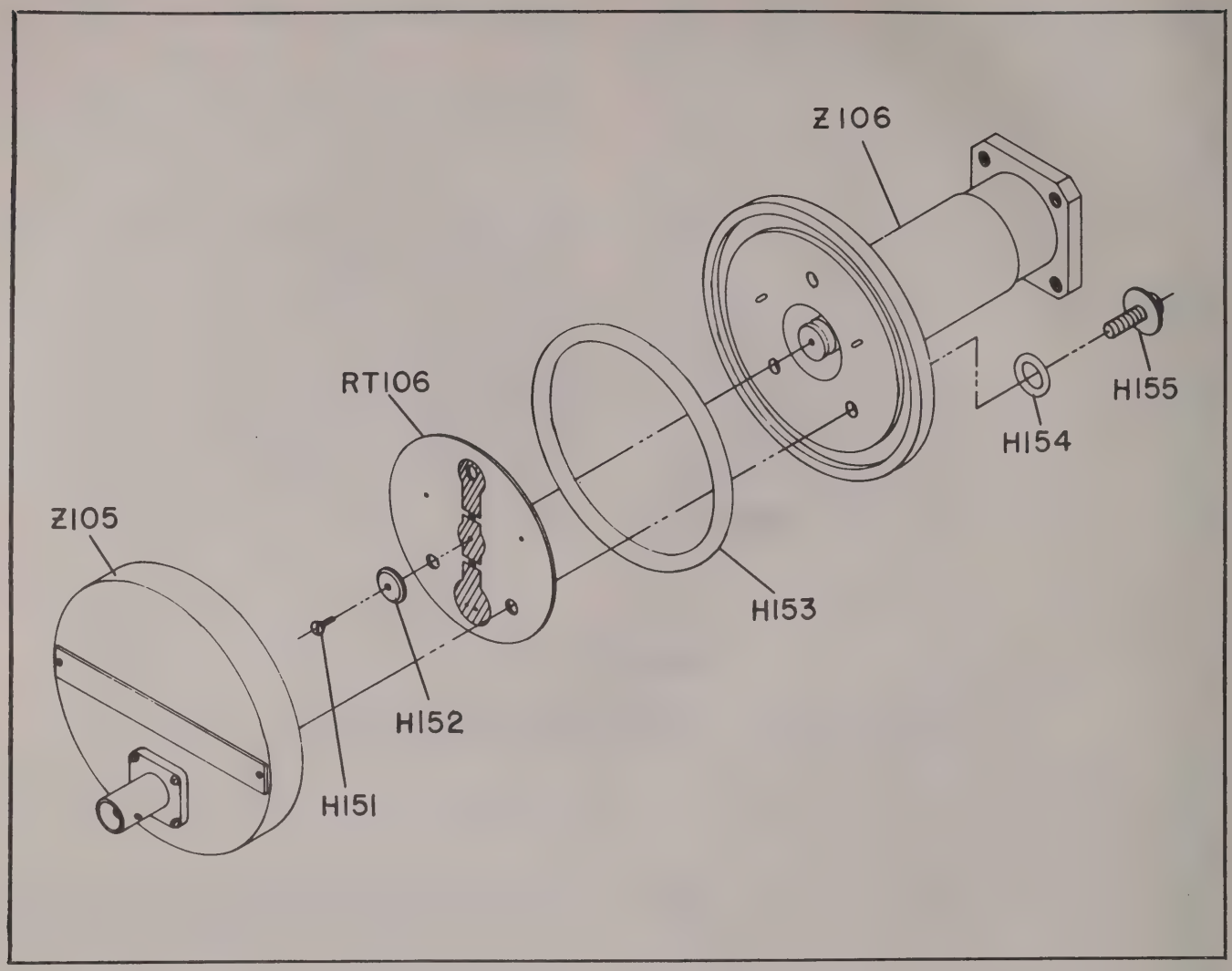

Figure 4-1. Bolometer Mount—Exploded View

package. Before inserting in mount, clean the mating surfaces of the mount to remove dust and fragments of the old bolometer element.

e. Slip the new bolometer element over the index pins of Z-106.

f. Replace the mounting screw, H-151, and washer, H-152.

g. Reassemble the two parts of the mount and replace the three clamping screws, H-155, and O-ring washers, H-154. Tighten the screws consecutively a little at a time until very tight.

h. Measure the resistance between the terminals of the dc connector of the mount. This should be approximately 220 ohms.

PART TWO

SERVICE INSTRUCTIONS

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SECTION I
DESCRIPTION AND LEADING PARTICULARS

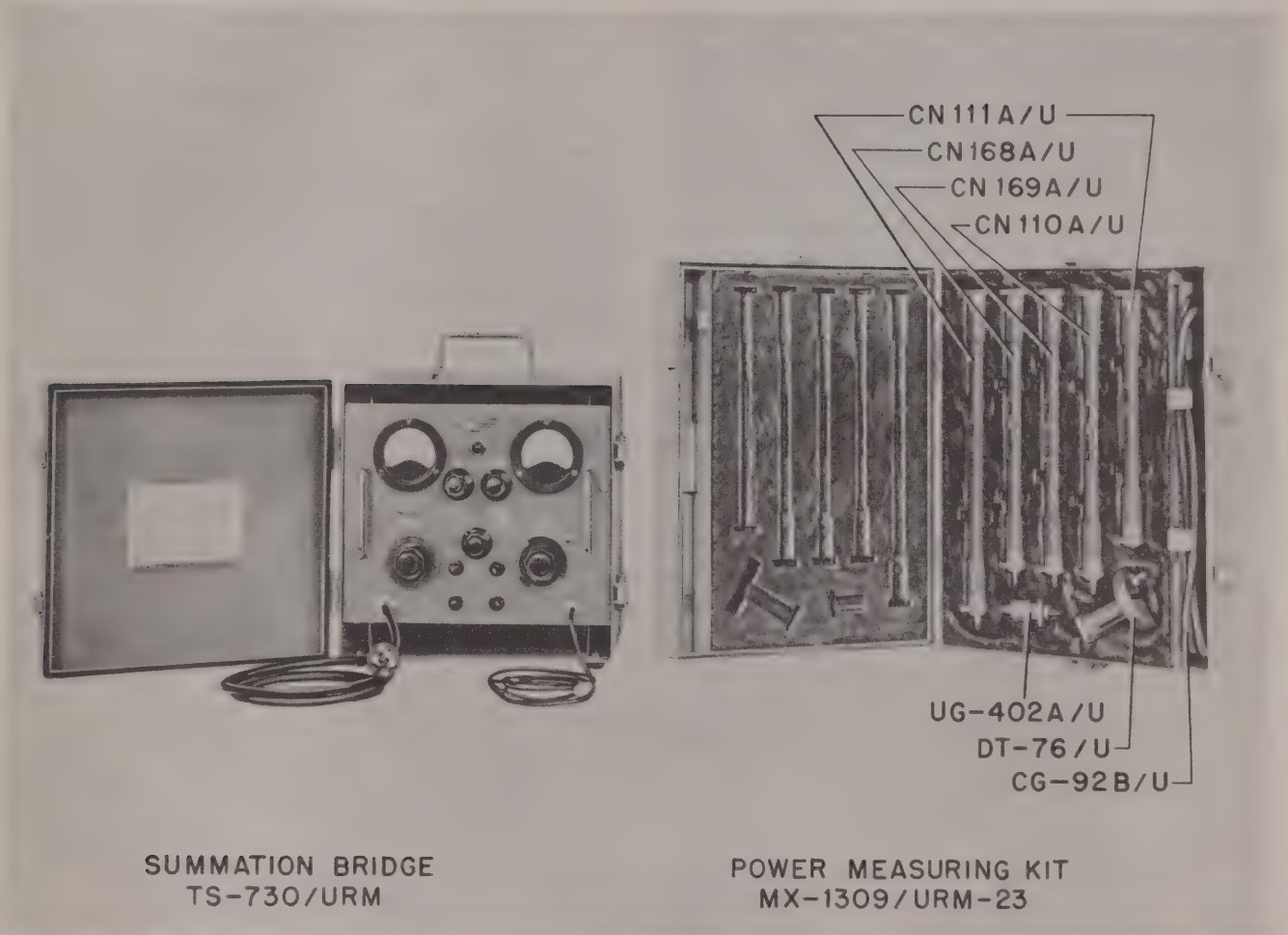


Figure 1-1. Summation Bridge AN/URM-23

1-1. INTRODUCTION.

1-2. IDENTIFICATION. This publication contains service instructions for Summation Bridge AN/URM-23 (see figure 1-1), manufactured by Bruno-New York Industries Corporation.

1-3. PURPOSE. Summation Bridge AN/URM-23 is an item of test equipment used to measure r-f power at frequencies between 1000 and 4000 megacycles per second. Its measurement range is from 5 to 50 milliwatts of average power, for the basic bridge. With the use of attenuators furnished as r-f accessories, the measurement capacity of the equipment may be extended to a maximum of 5 watts average power. Pulse modulated power may also be measured provided the maximum peak power does not exceed 2000 times the rated average power. The overall accuracy of power measurement is better than $\pm 15\%$ over the complete frequency and power ranges.

1-4. DESCRIPTION.

1-5. GENERAL. The equipment consists of two sections, Summation Bridge TS-730/URM, and Power Measuring Kit MX-1309/URM-23. Each section has its own aluminum case.

1-6. SUMMATION BRIDGE TS-730/URM. The bridge section contains two parts (1) a modified dc Wheatstone bridge with its associated calibration and metering circuits, and (2) the power supply which furnishes the electronically regulated bridge bias current. The bolometer element (see paragraphs 1-9 and 1-10) forms one leg of the Wheatstone bridge, which is in-

itially balanced with dc current only. When r-f power is added to the bolometer, its resistance changes, unbalancing the bridge. The bridge is rebalanced manually by subtracting dc current, and the dc power subtracted is a measure of the r-f power which was added. All operating controls and indicating meters are located on the front panel of the bridge. The entire assembly is panel-mounted so that removal of the panel from the case provides access to all parts. An aluminum angle frame fastened to the panel supports the major components and also acts as a set of runners to slide the panel assembly in or out of the case. Perforated metal screens are used on top and bottom of the assembly to allow the maximum amount of ventilation when the bridge is in operation. The unit operates from 115 volts ac, ±10%, 50-1000 cycles per second, drawing a line current of approximately 0.6 ampere. The tube complement is given in Table II of Section V.

1-7. POWER MEASURING KIT MX-1309/URM-23. This kit contains all the r-f components furnished for use with the bridge. These components are listed in Table I. Because the inner glass elements of the attenuators may be easily damaged by shock or vibration, specially-designed shock pads, which enclose the r-f components and provide protection while in transit, are built into the combination case. Twelve fastening screws to couple the r-f components together are also supplied.

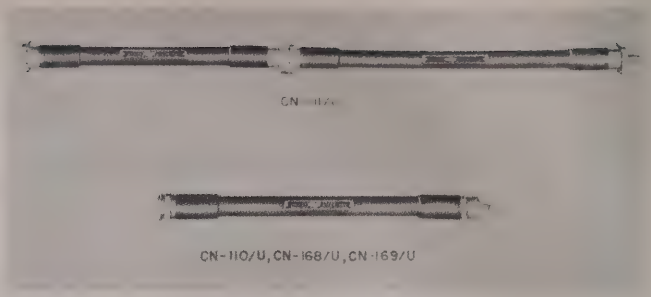


Figure 1-2. Attenuators

1-8. ATTENUATORS. *(See figure 1-2.)* The four attenuators supplied are all designed for 50-ohm, 7/8-inch

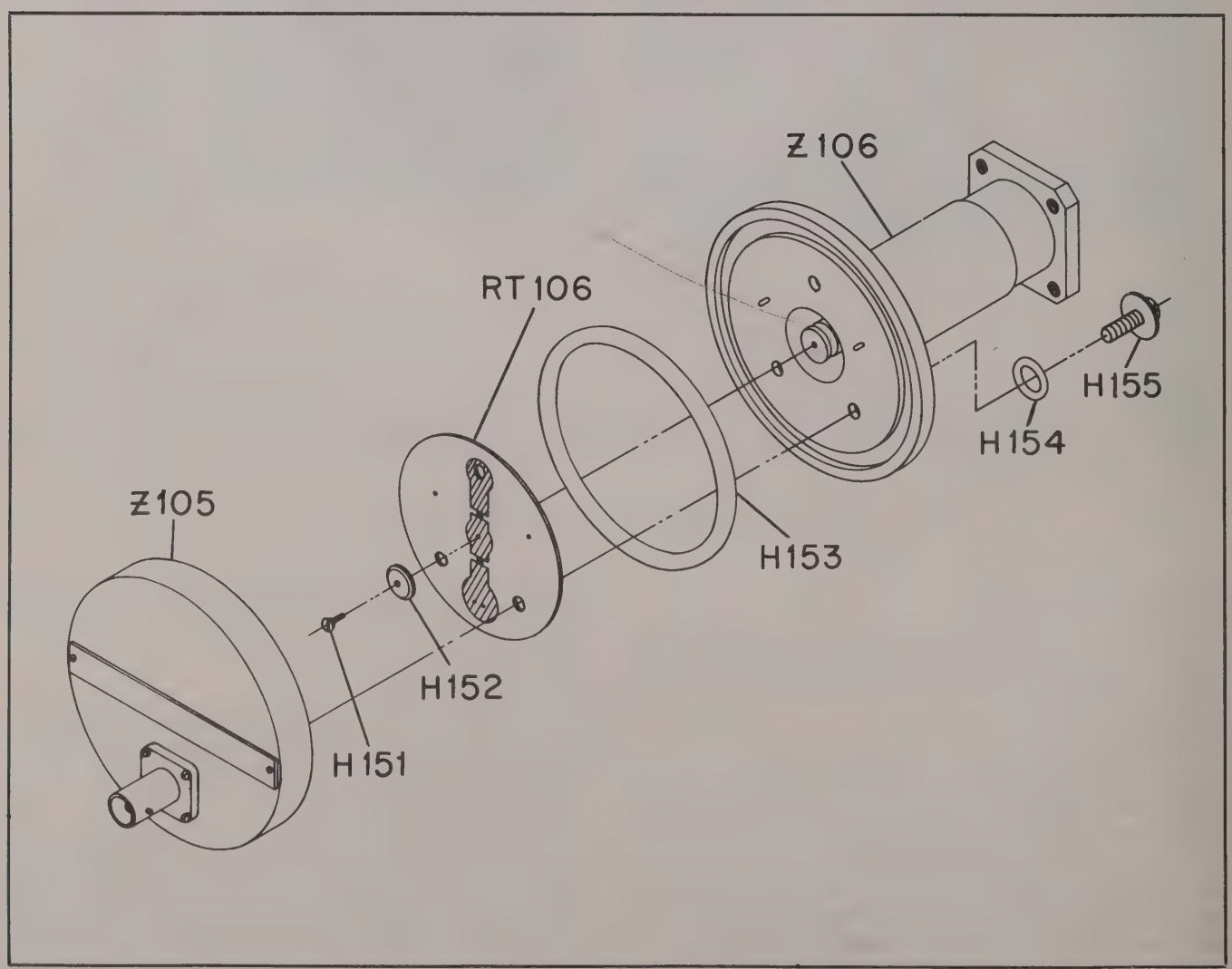


Figure 1-3. Bolometer Mount—Exploded View

Table I. Power Measuring Kit Components

Qty. Per Equipment	*Component*	*Type Designation*
1	R-F Attenuator (3 db, 5 watt)	CN-168A/U
1	R-F Attenuator (6 db, 3 watt)	CN-169A/U
1	R-F Attenuator (10 db, 1 watt)	CN-110A/U
1 (2 sections)	R-F Attenuator (20 db, 5 watt)	CN-111A/U
1	R-F Bolometer Mount (with element)	DT-76/U
1	Adapter Connector (3/8" to 7/8")	UG-402/U
1	R-F Cord	CG-92B/U
5	Bolometer Elements (spare)	—

rigid transmission line operation. The CN-110A/U, CN-168A/U and CN-169A/U attenuators have identical external physical dimensions and differ only in attenuation and power ratings. Each of these units is bidirectional, i.e., the r-f power may be introduced at either end. The CN-111A/U, a 20 db, 5 watt attenuator, is constructed in two sections which are coupled together when used. The CN-111A/U attenuator is unidirectional, and r-f power may be introduced only at the female end of the short section. The attenuator connectors are standard UG-45/U and UG-46/U couplings, except for the ends of the two sections of the CN-111A/U attenuator which couple together. Here non-standard couplings are used to prevent the possibility of using either section without the other. Each of these attenuators utilizes an inner conductor of glass tubing upon which is deposited an extremely thin metallized resistive coating. The broadband attenuation characteristics derive from the fact that this film thickness is small compared with the depth of penetration of the r-f field so that essentially flat attenuation is achieved over the rated frequency range. The Voltage Standing Wave Ratio for all attenuators is below 1.30 over the complete operating frequency range.

1-9. R-F BOLOMETER MOUNT DT-76/U. The bolometer mount is designed to house the bolometric element and provide r-f and dc connections so that the source of r-f (microwave) power may be coupled to the summation bridge. A UG-290/U receptacle is used to connect into the UG-88/U plug on the input cable of the bridge, while a UG-45/U connector connects the r-f system to the bolometric termination. A disassembled view of the bolometer mount is shown in figure 1-3. The bolometer element, RT-106, fits over the two index pins protruding from the face of the mount. These pins are located so that the bolometer cannot be fitted incorrectly into the mount. A mounting washer, H-152, and screw, H-151, secure the element to the front section, Z-106, of the mount. The rear section, Z-105, of the mount fits over the element, with an O-ring

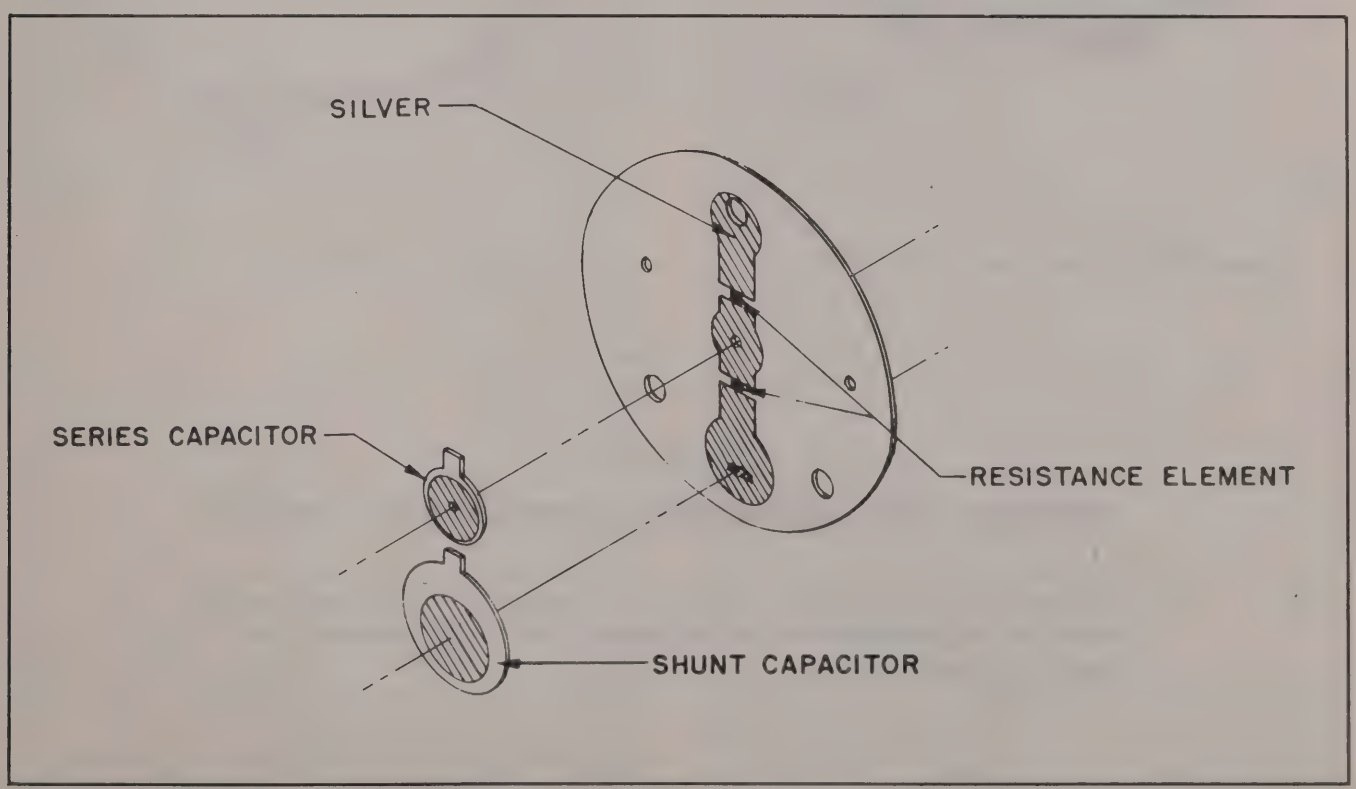


Figure 1-4. Bolometer Element

gasket, H-153, between the two sections to provide protection from moisture. The two sections of the mount are fastened together with three clamping screws, H-155, and O-ring washers, H-154. Since the bolometer element circuit ground is made against the face of the mount, it is essential that these clamping screws be extremely tight when the mount is used or a high-resistance or open connection will result. The procedure for changing bolometer elements in the mount is given in Section V.

1-10. BOLOMETER ELEMENT. *(See figure 1-4).* The bolometer element consists of a thin mica disc upon which are deposited two resistive carbon film sections, having nominal resistance of 100 ohms each at dc bias currents of 35 milliamperes. Two small bypass capacitors are mounted on the disc, connecting the carbon sections in parallel for incoming r-f signals, and in series for the dc bridge circuit. The bolometer element, in the mount, is designed for an average power range of 5 to 50 milliwatts, a maximum peak power of 100 watts, and has a VSWR of less than 1.30 over the complete frequency range. Five spare bolometer elements are supplied in a pocket of the r-f components case in the event of application of excessive power and burnout of the element in the mount.

1-11. ADAPTER CONNECTOR UG-402/U. *(See figure 1-5.)* This adapter is supplied as a means of converting from the $\frac{3}{8}$-inch coaxial cable to the attenuators or bolometer mount which are constructed for $\frac{7}{8}$-inch coaxial line.

1-12. CORD CG-92B/U. *(See figure 1-6.)* A six-foot length of $\frac{3}{8}$-inch coaxial cable, fitted at each end with a UG-21D/U plug, is supplied to couple the source of r-f power through the adapter, to the attenuators or bolometer mount. Attenuation values for this cable at three frequencies are stamped on a metal tag attached to the cable.

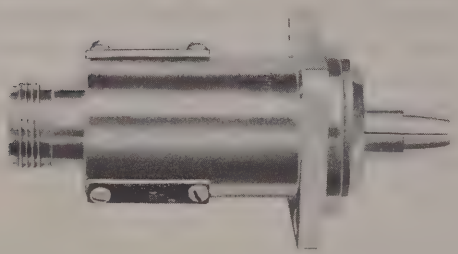


Figure 1-5. Adapter Connector UG-402/U

Figure 1-6. R-F Cord CG-92B/U

SECTION II

SPECIAL TEST EQUIPMENT AND SPECIAL TOOLS

2-1. No special test equipment or tools are necessary to service this unit. General-purpose test equipment such as an oscilloscope, tube tester, ohmmeter, etc., are required as indicated in Sections V and VI.

SECTION III
PREPARATION FOR USE AND RESHIPMENT

3-1. PREPARATION FOR USE.

3-2. This equipment, with all components, is completely self-contained in the two cases and is ready for use after uncrating.

3-3. PREPARATION FOR RESHIPMENT.

3-4. GENERAL. To prepare the equipment for packaging and shipment, simply store the various components in their appropriate place in the two cases.

3-5. PRESERVATION AND PACKAGING. The following method of preservation and packaging will, unless judgment, necessity, or specific order dictate otherwise, serve as a guide. The Summation Bridge AN/URM-23 shall be preserved in unit containers in accordance with Specification MIL-P-116A, Method II. The procedure is as follows:

a. Place each of the two cases in an individual corrugated cardboard box. Secure the cases in place with suitable cardboard cutouts or other blocking means.

b. Add suitable dehydrating agent conforming to Specification MIL-D-3464. The quantity required depends upon the cubic volume of the container, but 12 ounces for the box containing each case will be sufficient in most cases.

c. Seal cartons with gummed tape conforming to Specification JAN-P-127 and place each carton within a moisture-barrier conforming to Specification AN-P-13A. Insert humidity indicator conforming to drawing AN-75-13 into moisture barriers.

d. Heat-seal edges of both barrier containers with hot iron.

e. Place each inner container and barrier within its individual second carton which should be of moisture-impervious material conforming to Specification MIL-C-6056. Seal with tape as in step (c).

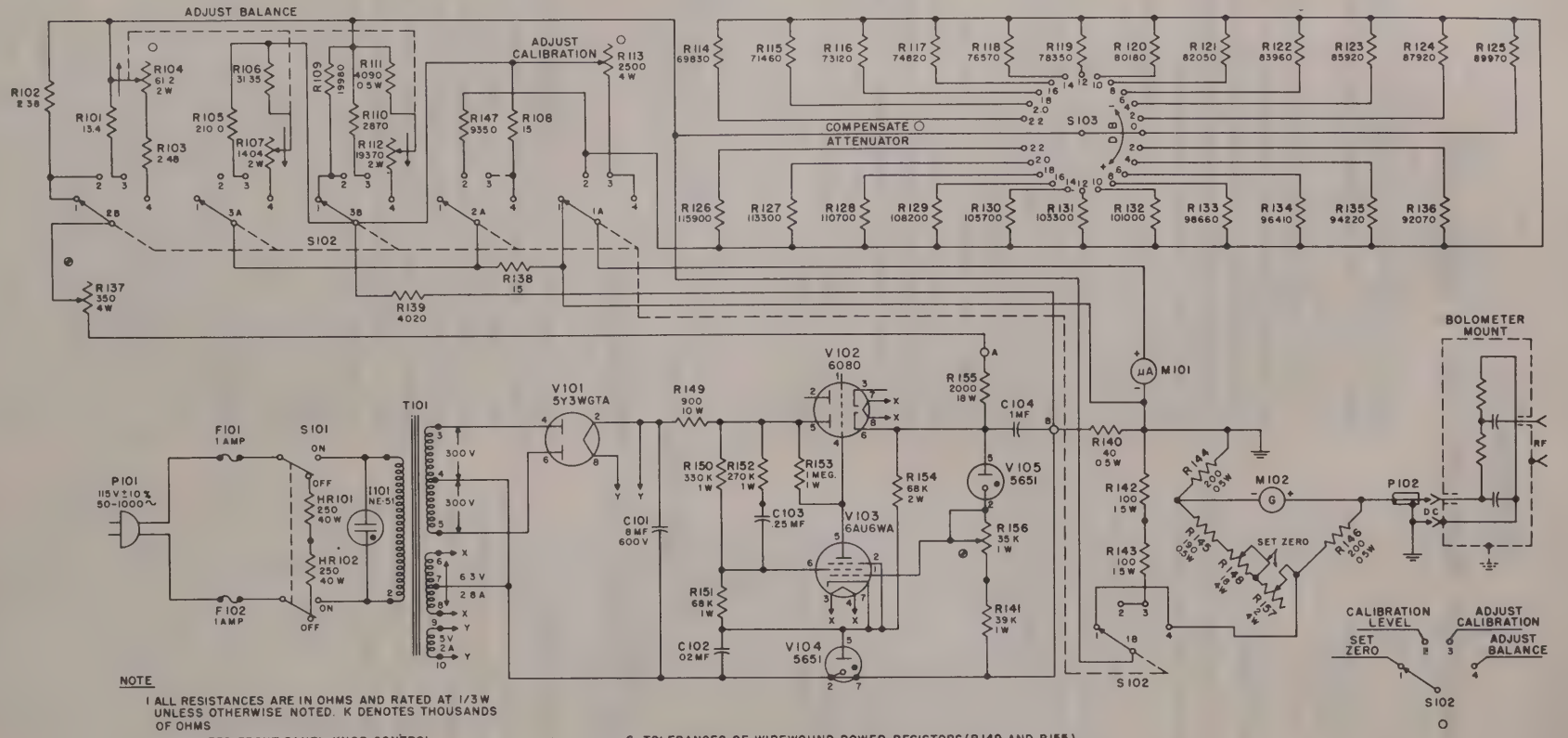
f. Pack the cartons in a shipping case, adding bracing as required to keep the cartons from moving. If packed for domestic shipment, a corrugated cardboard carton conforming to Consolidated Freight Regulations may be used. For export shipment, a wood case conforming to the requirements of Specification JAN-P-106A is required.

SECTION IV
THEORY OF OPERATION

4-1. GENERAL THEORY OF OPERATION.

4-2. INTRODUCTION. The theory of operation, range and sensitivity of Summation Bridge AN/URM-23 are based upon the resistance-temperature characteristic of the bolometer. A bolometer is a small resistive element whose resistance is proportional to temperature and therefore to the average power dissipated in the element and the rate at which heat is conducted away through its mount. If the bolometer is designed properly, this resistance-temperature characteristic (or resistance-power characteristic for a given mount) may be made essentially independent of the frequency of power applied. Thus a resistance change caused by the application of r-f power can be counterbalanced by an opposite resistance change due to the subtraction of an equivalent amount of dc power. The measurement of this subtracted dc power by a summation-type bridge circuit therefore gives an accurate value for the original r-f power applied. In Summation Bridge AN/URM-23, the bolometric element serves as one of the arms of a balanced dc Wheatstone bridge and in addition provides a matched 50-ohm termination for the r-f input. In this manner both dc and r-f currents flow through the bolometer. The resulting resistance and final temperature of the element is directly determined by both currents. In commencing a measurement the bridge is first balanced with a dc bias current of approximately 35 milliamperes flowing through the bolometer element. This sets the operating temperature and resistance of the element. The r-f source is then connected to the bolometer mount whereupon the additional r-f power changes the element resistance and unbalances the bridge. The bridge is now rebalanced by reducing the dc bias current until the bolometer element returns to its former equilibrium resistance. A metering circuit interprets this reduction of bias current in terms of r-f power which is then indicated on a meter calibrated directly in milliwatts of power.

4-3. SUMMATION BRIDGE TS-730/URM. The complete schematic diagram of the Summation Bridge is shown in figure 4-1. The circuit may be divided into two sections, (1) the bridge section, and (2) the power supply. These will be discussed separately.



NOTE

1. ALL RESISTANCES ARE IN OHMS AND RATED AT 1/3W UNLESS OTHERWISE NOTED. K DENOTES THOUSANDS OF OHMS
2. ○ DENOTES FRONT PANEL KNOB CONTROL.
3. ◎ DENOTES INTERNAL ADJUSTMENT.
4. SWITCH S102 SECTIONS NUMBERED FROM SHAFT END AND LETTERED FROM LEFT TO RIGHT
5. ALL CAPACITANCES ARE IN MICROFARADS DC WORKING VOLTAGES ARE 600 VOLTS UNLESS OTHERWISE SPECIFIED
6. TOLERANCES OF WIREWOUND POWER RESISTORS (R149 AND R155) AND ALL COMPOSITION RESISTORS (R141, R150 THROUGH R154) ARE ±5%. TOLERANCES OF ALL WIREWOUND PRECISION RESISTORS ARE ±½%. TOLERANCES OF ALL CAPACITANCES ARE ± 10%.

Figure 4-1. Schematic Diagram, Summation Bridge

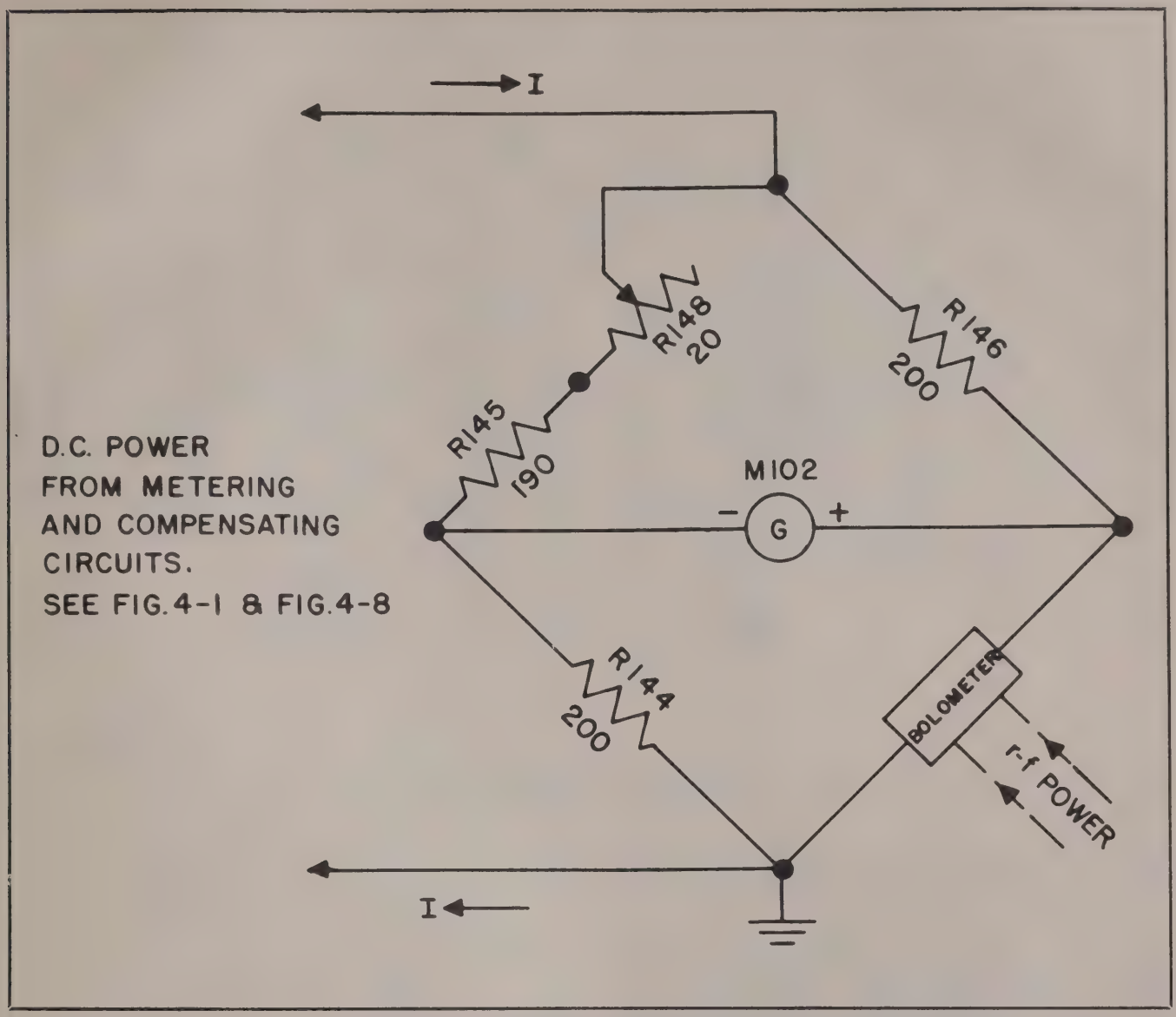


Figure 4-2. Simplified Diagram, Bridge Section

4-4. BRIDGE SECTION. *(See figure 4-2).* A simplified diagram of the bridge section is illustrated. The bridge is designed to operate as a conventional equal-arm Wheatstone bridge, with the nominal resistance of each arm 200 ohms. The "SET ZERO" control, R-148, allows the bridge to be balanced for a ± 10 ohm variation in bolometer resistance from its nominal value. With the selector switch, S-102, in the "SET ZERO" position, and with no r-f power applied, the bridge is initially balanced by varying R-148. During this step the power metering circuit and bridge attenuator are disconnected by the selector switch. As a result, a dc bias current of approximately 70 milliamperes flows from the power supply through the bridge, dividing so that 35 milliamperes flows through the bolometer. The bias current brings the operating resistance of the bolometer element to a nominal 100 ohms for each of its two sections. With the selector switch in the "ADJUST BALANCE" position, when r-f power is applied, the temperature of the bolometric element rises still further, resulting in an additional change in resistance. (Since the temperature coefficient of carbon is negative, the bolometer resistance decreases with increasing power and temperature). This variation in the resistance of the bolometer from the balance condition causes a bridge unbalance current to flow through the galvanometer, M-102. The "ADJUST BALANCE" position of the selector switch also connects the bridge attenuator (triple-ganged potentiometer R-104, R-107, R-112) into the circuit. Bridge balance is restored by adjusting the bridge attenuator so that some of the dc bias current is removed. Balance reoccurs when the power supplied to the bolometer by the r-f source is just counter-balanced by the dc power removed by the reduction of the bias current. For this type of measurement to be accurate, the dc bias current must be constant throughout a single measuring

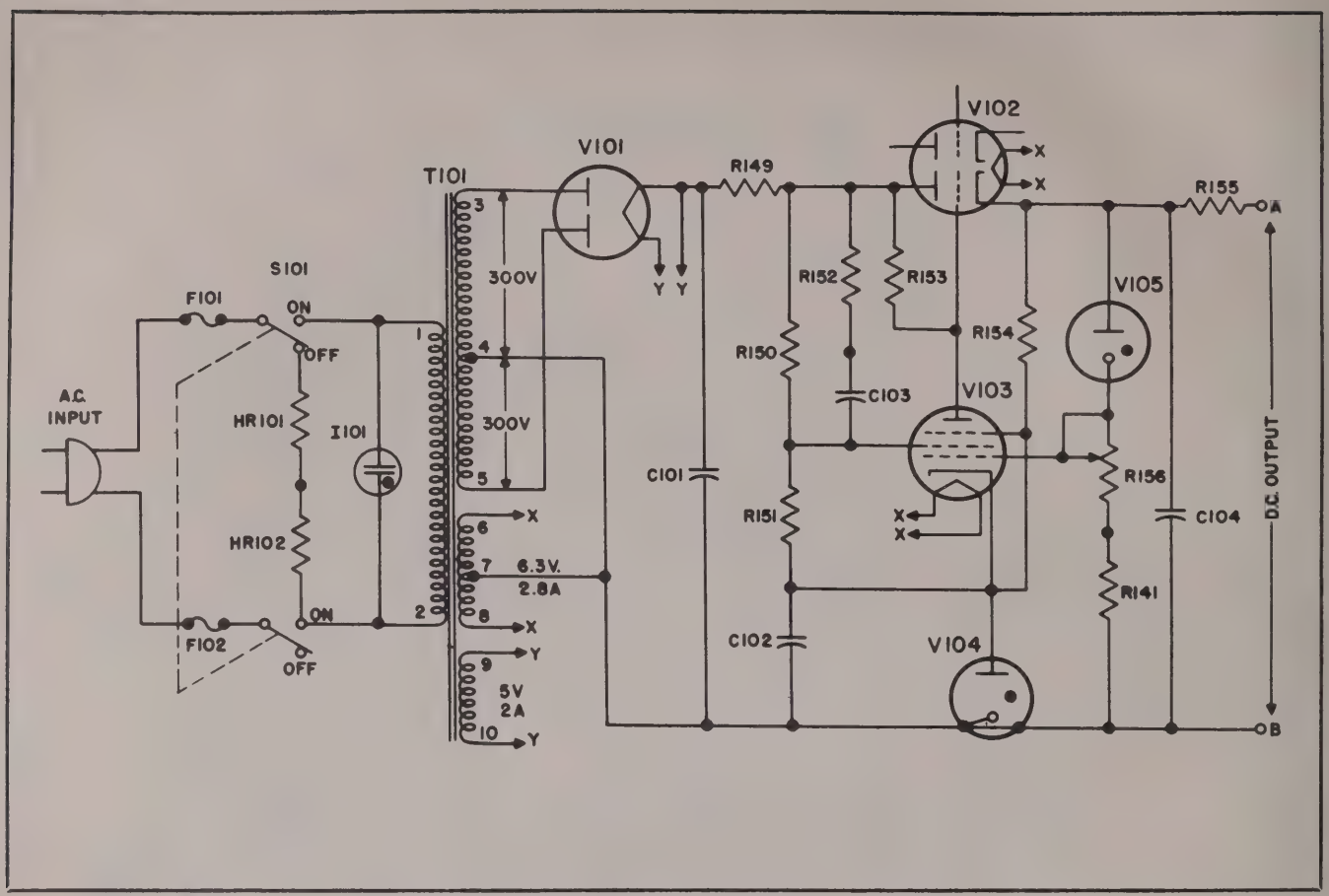


Figure 4-3. Schematic Diagram, Power Supply

operation. The bridge circuit is therefore designed to offer a constant impedance to the power supply for all positions of the operating controls.

4-5. POWER SUPPLY. *(See figure 4-3).* The power supply is designed to furnish the dc bias current required by the bolometer and the bridge circuit. Since the accuracy of measurements made with this equipment is based upon the constancy of the bias current throughout the measuring period, the power supply is electronically stabilized and regulated. A conventional series regulator control circuit is used, with refinements to obtain closer regulation and reduction of ripple voltage. A variation of $\pm$ 10% in ac line voltage will cause a change in bias current of less than $\pm$ 0.2%. Ripple voltage is reduced to less than 0.05% by means of a hum-bucking feedback circuit.

4-6. DETAILED THEORY OF OPERATION.

4-7. BOLOMETER ELEMENT. Figure 4-4 is a schematic representation of the bolometer element showing the r-f input and dc bridge connections. At r-f frequencies the two blocking capacitors have negligible reactance and may be considered as short-circuits. The effective r-f input path, therefore, parallels the two 100-ohm carbon resistance sections to produce a 50-ohm termination to the r-f circuit. For dc, however, the resistive sections are in series to total 200 ohms and act

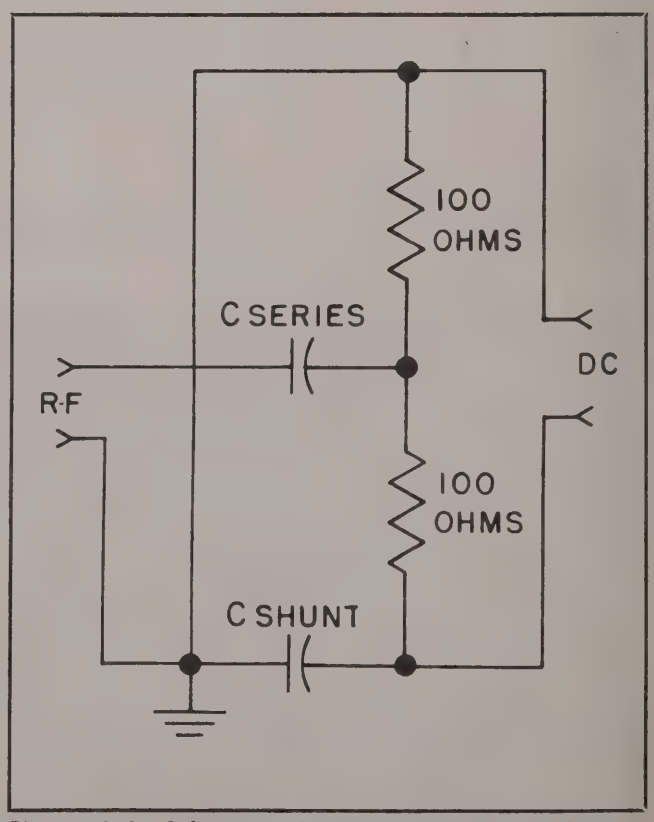


Figure 4-4. Schematic Diagram, Bolometer Element

as one arm of the bridge. The bolometer element therefore simultaneously dissipates r-f and dc power, and its exact resistance is proportional to the *total* power.

4-8. SUMMATION BRIDGE. The detailed operation of the bridge will be discussed separately for each of the four selector switch positions, "SET ZERO", "CALIBRATION LEVEL", "ADJUST CALIBRATION", and "ADJUST BALANCE".

4-9. SELECTOR SWITCH AT "SET ZERO". With the selector switch, S-102, at the "SET ZERO" position, the bridge section reduces to the diagram of figure 4-5. The power supply furnishes the dc bias current required to heat the bolometer to its operating resistance. The current I is approximately 70 milliamperes and since it divides equally between the arms of the bridge the dc bias current through the bolometer will be 35 milliamperes. In this selector switch position, no r-f power is being fed to the bolometer so that the bridge galvanometer, M-102, may be initially balanced with R-148, the "SET ZERO" control.

4-10. SELECTOR SWITCH AT "CALIBRATION LEVEL". With the selector switch in the "CALIBRATION LEVEL" position, the circuit becomes as shown in figure 4-6. For calibration purposes, the bridge is now replaced by two fixed 100-ohm resistors, R-142 and R-143 in series, and the bolometer is therefore out of the circuit. The power meter, M-101, reads a current which varies only with changes in total bias current I or changes of resistors R-114 through R-136. The bias current, for a given set of components, will vary only with ambient temperature, so that the variations in calibration level read by M-101 will depend only upon temperature and attenuation compensation data. The value of R-114 through R-136 depends upon the setting of the "COMPENSATE ATTENUATOR" control, S-103, which in turn is dependent upon the calibration data for the attenuator used at the particular frequency and ambient temperature. This resistor, in series with meter M-101 and its mutlipliers, reduces the meter current by a predetermined amount, so that the deviation

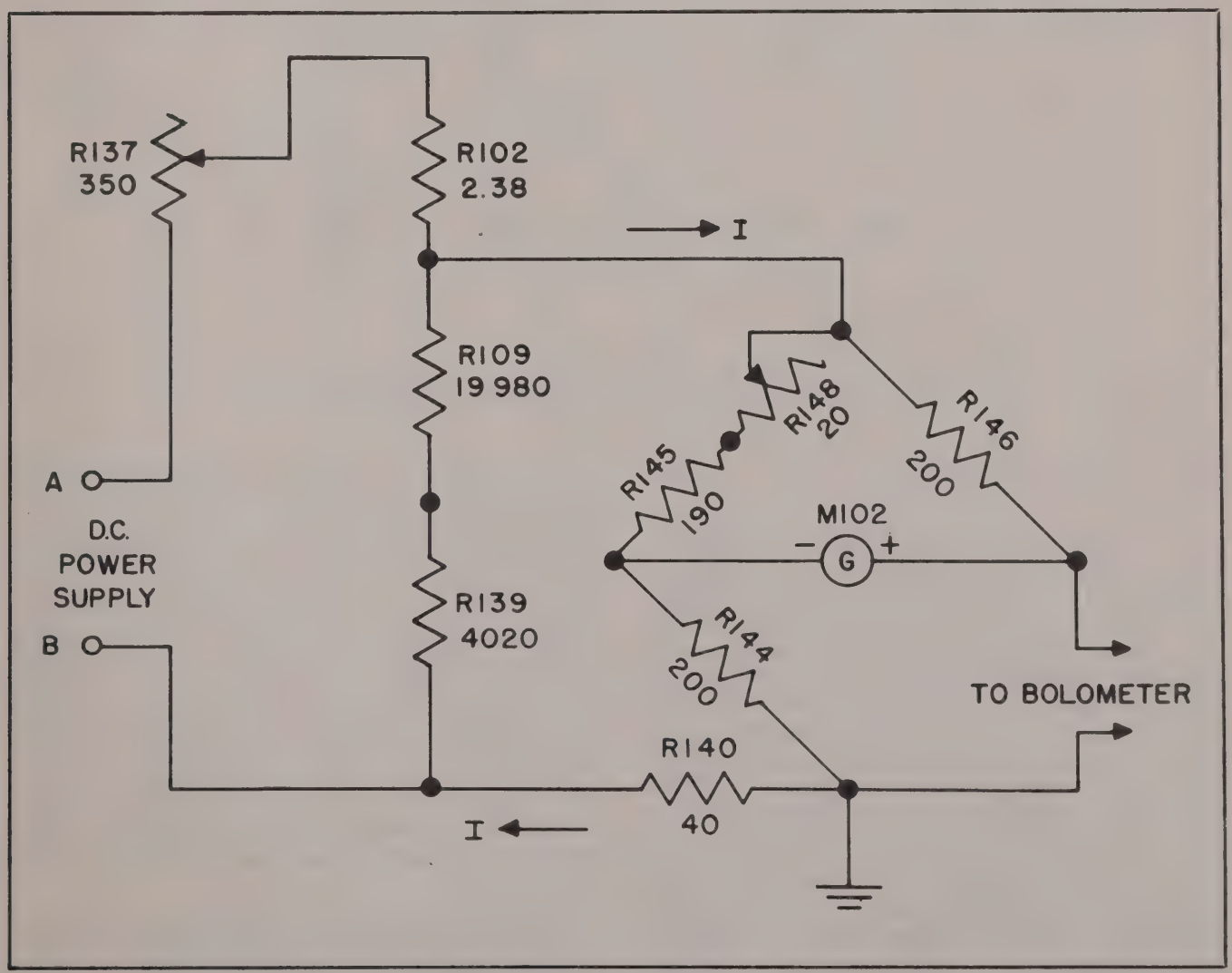


Figure 4-5. Simplified Circuit, Selector Switch at "SET ZERO"

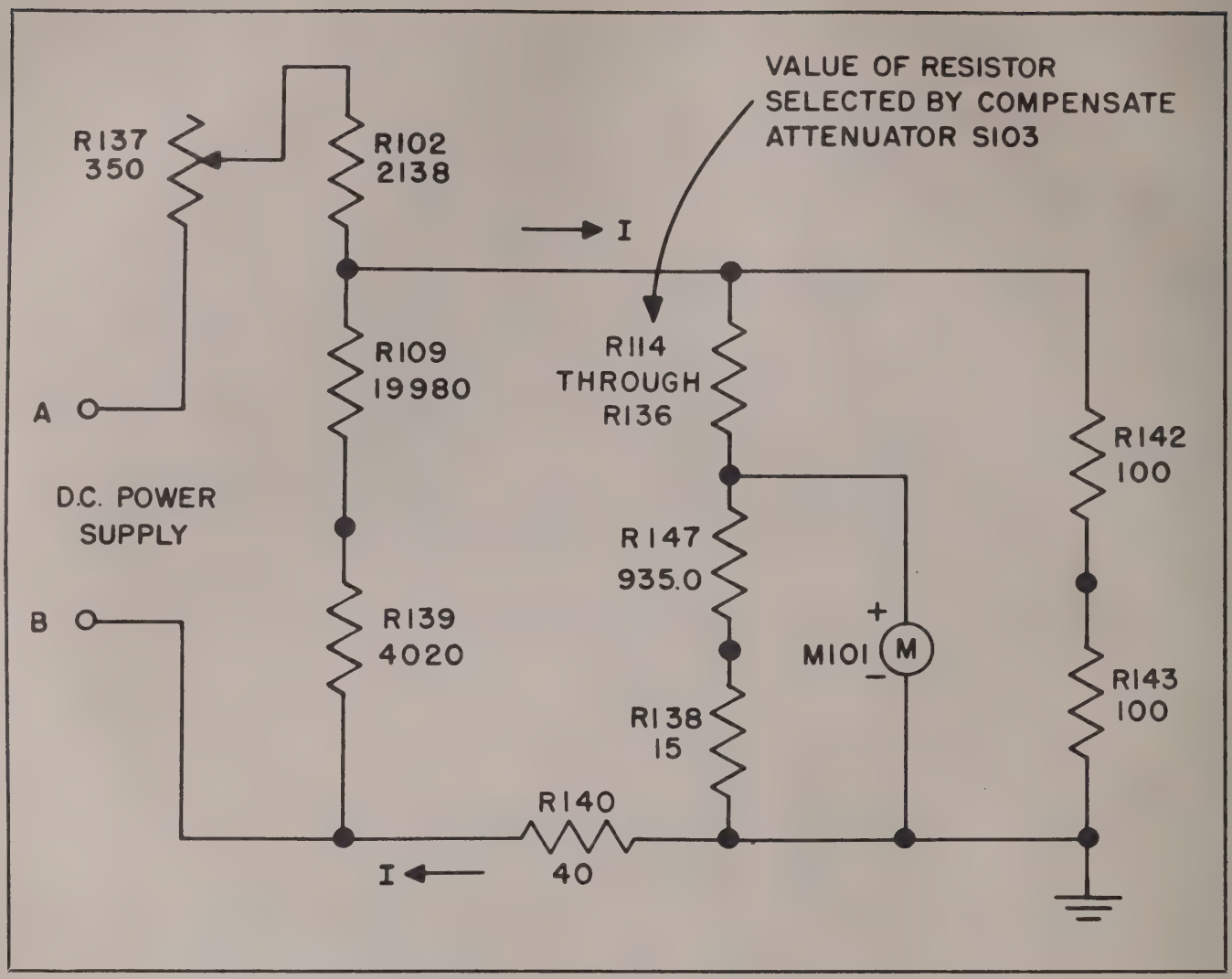


Figure 4-6. Simplified Circuit, Selector Switch at "CALIBRATION LEVEL"

of the r-f attenuators from nominal values is compensated for.

4-11. SELECTOR SWITCH AT "ADJUST CALIBRATION". When the selector switch is in the "ADJUST CALIBRATION" position, the "ADJUST CALIBRATION" control, R-113, is directly in series with the power meter, M-101, as shown in figure 4-7. This additional series resistance varies the current through the meter and allows the meter sensitivity to be adjusted for variations in attenuation compensation data whose calibration level was determined in paragraph 4-10. R-113 remains in the meter circuit in the "ADJUST BALANCE" position, when power measurements are being made.

4-12. SELECTOR SWITCH AT "ADJUST BALANCE". With the selector switch in the "ADJUST BALANCE" position, the circuit reduces to figure 4-8. The bridge replaces the fixed calibration resistors, and the triple-ganged potentiometer attenuator, R-104, R-107, R-112, is inserted into the bias current and metering circuits. This potentiometer is designed and ganged so that the attenuation factor of all three sections is the same for all positions. Thus, after r-f power is applied to the bolometer, the value of attenuation factor in the bridge attenuator, R-104, that results in bridge balance is auomatically reproduced in the meter attenuators, R-112 and R-107. The r-f power input is equal to the equivalent dc power subtracted manually by rebalancing the bridge. This dc power is subtracted by reducing the dc bias current through an increase in the resistance value of R-104. Since this variation in bias current is reproduced in the meter circuit, both the reading of M-101 and the r-f power are proportional to the dc bias variation. The reading of M-101 and the r-f power are therefore proportional to each other.

4-13. BIAS CURRENT COMPENSATION. Referring to figures 4-5 through 4-8, it may be seen that in the "SET ZERO" and "CALIBRATION LEVEL" positions of the selector switch an additional fixed L-pad, con-

sisting of resistors R-102, R-109 and R-139 is placed across the output of the power supply. This is removed in the "ADJUST CALIBRATION" and "ADJUST BALANCE" positions of the switch, thus increasing the bias current. Because of this increase in bias current the meter attenuators, R-112 and R-107, must bypass a larger current from the bridge in order to restore balance. This is desirable, since otherwise the very small shunt currents which normally would be required for measurement of small r-f powers would require excessively large values for R-112 and R-107. The effect of this boost in bias current in the "ADJUST CALIBRATION" and "ADJUST BALANCE" positions is compensated exactly in the meter circuit by the introduction of R-139, which has the function of bleeding the proper amount of current from the meter circuit to compensate for the boost in bias current. Thus the power reading of M-101 contains no error due to the introduction of the compensating circuit, whose purpose is to keep the resistance ranges for the sections of the triple-ganged potentiometer at practical manufacturing values.

4-14. POWER SUPPLY. The circuit for the power supply section of the Summation Bridge is shown in figure 4-3. The supply is closely regulated and stabilized to maintain a constant bias current to the bridge and bolometer. The circuit is that of a modified series regulator which acts so as to cancel any attempted fluctuation of its output voltage, whether caused by variations in input line voltage or output load impedance. A portion of the output voltage is fed from R-156 to the control grid of the amplifier tube, V-103. Since the cathode of V-103 is held at a fixed point above ground by voltage-reference tube, V-104, any attempted variation in output voltage is amplified by V-103 and appears in inverted form across R-153, which also serves to establish the plate resistance and operating bias of series tube V-102. Because the amplified fluctuation and the original fluctuation are opposite in phase, cancella-

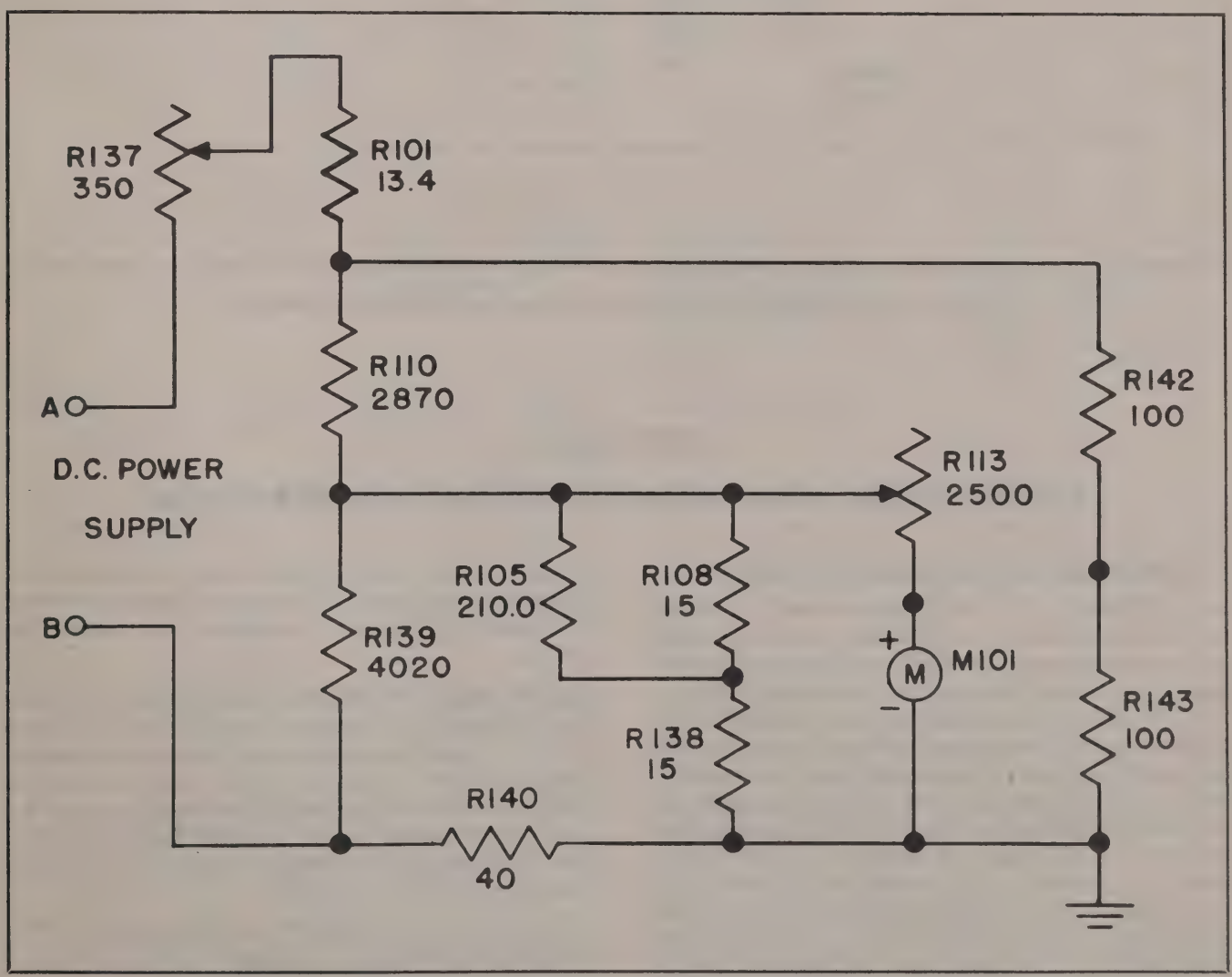


Figure 4-7. Simplified Circuit, Selector Switch at "ADJUST CALIBRATION"

tion will occur, giving as the end result an almost ripple-free output across A and B. Tube V-105 maintains a constant voltage between the high side of the output and the control grid of V-103 and allows additional regulation. R-153 and C-103 form a hum-bucking path to the screen grid of V-103, maintaining a fixed dc screen grid bias but allowing any ac ripple to reach the screen grid and be amplified and reversed through V-103 as described above. Thus the ripple voltage in the output is still further reduced.

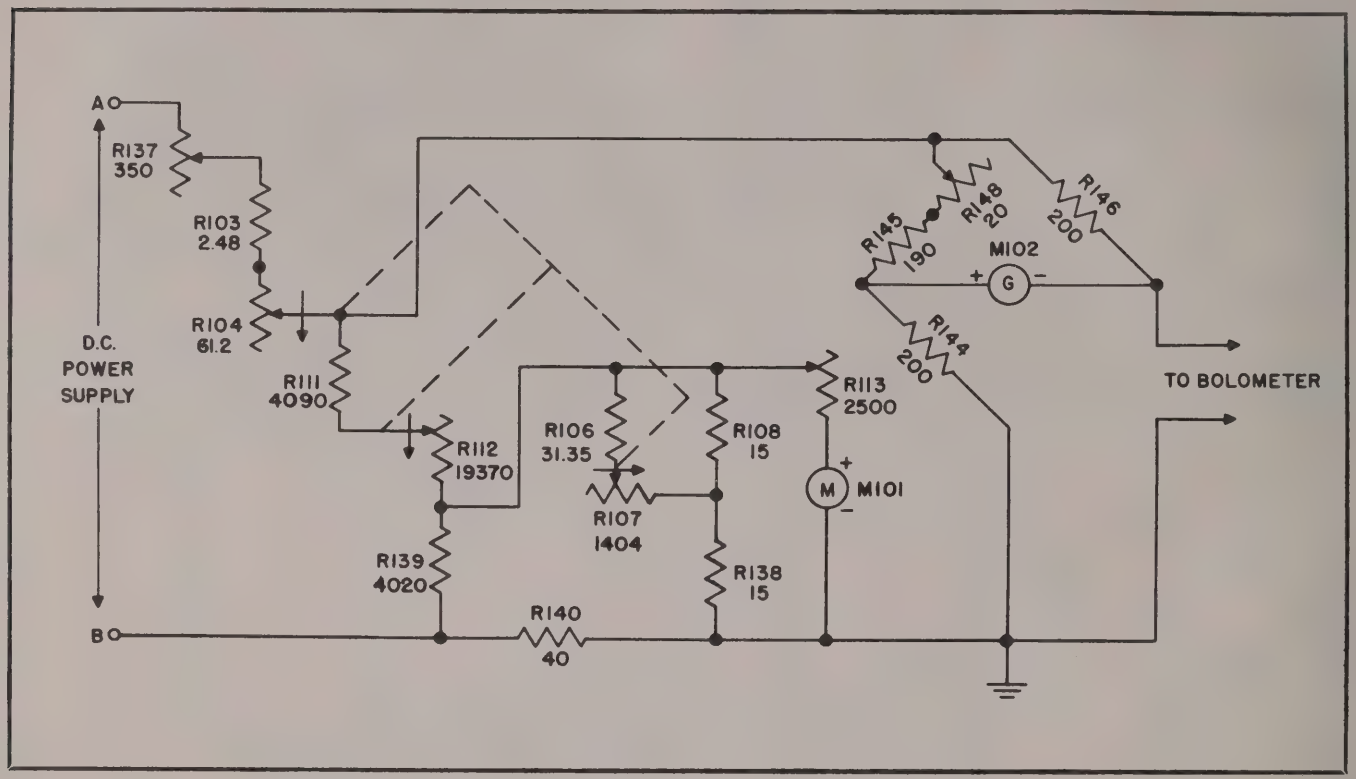


Figure 4-8. Simplified Circuit, Selector Switch at "ADJUST BALANCE"

SECTION V

OPERATIONAL AND ORGANIZATIONAL MAINTENANCE

5-1. MINIMUM PERFORMANCE STANDARDS.

5-2. GENERAL. The overall performance requirement for Summation Bridge AN/URM-23 is that the accuracy of any power measurement over the complete frequency, power and temperature ranges be within ± 15% of the true value. Since absolute standards of r-f power at frequencies between 1000 and 4000 megacycles per second are rarely encountered except in laboratory use, for practical test purposes it may be assumed that the standard of true power would be the measurement indicated by a Summation Bridge in good working order, or preferably, the average of the readings of several such bridges. Thus if measurements taken with a standard bridge are within ± 15% of the values indicated on the bridge under test, the test unit may be considered as meeting the overall minimum performance standards. If the overall accuracy is out of tolerance, the tests and trouble-shooting procedures described in paragraphs 5-6 through 5-9 must be followed to isolate and repair the particular part causing the trouble.

5-3. SUMMATION BRIDGE TS-730/URM. The primary minimum performance standard for the bridge section is again the comparative power measurement. Using the same bolometer mount and element, the bridge under test should measure within ± 5% of the full-scale indication on the standard bridge. In addition, all controls should operate smoothly and the meter movements should not stick.

5-4. BOLOMETER MOUNT AND ELEMENT. The minimum performance standards for the bolometer mount and element include initial operating resistance, power capacity and linearity of power measurements.

The initial operating resistance of the bolometer element, with only its dc bias current of 35 milliamperes, should be such that the "SET ZERO" control, R-148, can balance the bridge at any ambient temperature between —40°C. and +55°C. The power capacity of the element should enable it to dissipate continuously at least 50 milliwatts of r-f power, in addition to the dc bias current, without changing any of the element characteristics. Finally, the power readings indicated on a bridge using first a standard bolometer and then the bolometer under test should match, for any r-f power level between 5 and 50 milliwatts, to within ± 5% of full-scale readings.

5-5. ATTENUATORS. The performance requirement for each of the attenuators is that, after the proper compensation setting on the "COMPENSATE ATTENUATOR" control is added, the r-f power should be reduced in accordance with the nominal rating of the attenuator, within 5% of full-scale indication. If a power measurement made with the bolometer alone, for example, indicates 50 milliwatts, then the introduction of the 3 db attenuator should result in a new power reading of 25 milliwatts ± 2.5 milliwatts. In addition to this accuracy requirement, the 3, 6 and 10 db attenuators must each be able to withstand an average power of ½ watt, while the 20 db attenuator must withstand 5 watts.

5-6. TESTING AND TROUBLE ANALYSIS.

5-7. SUMMATION BRIDGE TS-730/URM. If the bridge does not meet the minimum performance standards outlined in paragraph 5-3, the test procedure indicated in Table II should be followed:

Table II. Operational Trouble-Shooting Chart — Bridge

Procedure	*Normal Indication*	*Abnormal Indication*	*Possible Causes of Abnormal Indication*
1. Connect bolometer to bridge. Connect power plug to 115V. ac source. Turn power switch, S-101, "ON"	I-101 should light up.	No indication on I-101	(a) Fuses F-101, F102 blown. (b) Lamp I-101 blown. (c) Primary of transformer T-101 shorted. (d) Plug P-101 or power cable defective
2. Rotate selector switch, S-102, to "SET ZERO". After warm-up, rotate "SET ZERO" control, R-148.	Clockwise rotation of R-148 should move M-102 pointer from left to right, counter-clockwise rotation from right to left.	(a) Pointer of M-102 deflects sharply to right, cannot be balanced. (b) Pointer of M-102 deflects sharply to left, cannot be balanced. (c) No movement of M-102 pointer	(a) Bolometer element or mount open-circuited. Replace element and retest. (b) Bolometer element or mount short-circuited. Replace element and retest. (c) M-102 defective, or power supply inoperative.
3. Balance bridge with R-148. Rotate S-102 to "CALIBRATION LEVEL"	M-102 pointer should be balanced at zero. M-101 should indicate above half-scale reading	No reading on M-101	(a) M-101 defective (b) S-102 defective (c) Open-circuit in wiring
4. Rotate "COMPENSATE ATTENUATOR" control through all positions.	M-101 readings should be between half and full scale and show small, progressively decreasing readings as control is rotated clockwise.	No reading or abnormally high reading of M-101 at any particular control position.	Short-circuit or open-circuit of compensation resistor connected to that position of control.
5. Rotate S-102 to "ADJUST CALIBRATION." Rotate "ADJUST CALIBRATION" control, R-113, clockwise.	M-101 readings should vary from approximately 20% of full-scale to at least full-scale	Low or high reading of M-101	(a) R-113 defective (b) S-102 defective
6. Rotate S-102 to "ADJUST BALANCE". Rotate "ADJUST BALANCE" control, R-104, R-107, R-112, fully counterclockwise.	M-102 and M-101 readings should be zero. Reset M-102 to zero with R-148 if necessary	Reading of M-101 does not reduce to zero	(a) R-104, R-107, R-112 defective (b) S-102 defective
7. Rotate "ADJUST BALANCE" control clockwise.	M-102 should deflect clockwise, M-101 reading should increase to more than full scale	(a) M-102 deflects counterclockwise (b) M-101 reading does not reach full scale	(a) M-102 leads reversed (b) "ADJUST BALANCE" control R-104, R-107, R-112 defective.

5-8. BOLOMETER MOUNT AND ELEMENT. If a balance cannot be obtained on the bridge galvanometer for a particular bolometer, turn off the power switch and disconnect the bolometer mount from the bridge cable. Measure the resistance between the terminals of the dc connector of the bolometer mount with an ohmmeter. The reading should be approximately 220 ohms. This is the cold resistance of the bolometer element and, since the resistive material is carbon which has a negative resistance-temperature coefficient, will drop to 200 ohms when the proper bias current of 35 milliamperes flows through it. If the correct resistance value is not obtained, replace the bolometer element as described in paragraph 5-13.

5-9. ATTENUATORS. No maintenance is possible on attenuators. They must be completely replaced if defective. An actual power measurement with and without the doubtful attenuator in the circuit to determine whether the performance standards of paragraph 5-5 are met is the best test. If no r-f power source is available, a secondary check on attenuators may be made by measuring the dc resistance between both ends of the inner conductor. The values which should be obtained are listed in Table III, and deviations from these values would indicate defective units. If one section of the 20 db attenuator is defective, the complete attenuator must be replaced.

Table III. Attenuator DC Resistance*

Attenuator	*DC Resistance*
CN-110A/U (10 db)	109.6 ± 3 ohms
CN-111A/U (20 db, Section 1)	42.6 ± 2 ohms
CN-111A/U (20 db, Section 2)	165 ± 3 ohms
CN-168A/U (3 db)	32.1 ± 1.5 ohms
CN-169A/U (6 db)	65.4 + 3 ohms

* See paragraph 5-9.

5-10. REPLACEMENT OF PARTS.

5-11. SUMMATION BRIDGE TS-730/URM. The bridge pilot lamp, I-101, and fuses, F-101 and F-102, are accessible at the panel without disassembly. If the pilot lamp is inoperative, unscrew the plastic cap over the lamp, remove lamp and replace. If either or both fuses is burned out, replace with spare fuses located directly below the active fuse posts on the panel. For replacement of tubes, see paragraph 5-12. The method of replacement for other parts, such as resistors, capacitors, meters, etc., is in general obvious. Because of the nature of the circuit, the value of all components is highly accurate. If a replacement is required, the new component must be of the correct value and tolerance. It is undesirable to replace any of the precise wirewound resistors with composition resistors, even though of selected value, because the resistance of this latter type will drift with time.

5-12. REPLACEMENT OF TUBES AND RECALIBRATION. The tube complement of the bridge is given in Table IV. To replace tubes, remove the bridge from its combination case by unfastening the two outside rows of screws which connect the panel to the case. Unscrew the four screws on the right-hand side plate and remove plate to make tubes accessible. Refer to schematic diagram on plate or to diagram of figure 4-1 to identify tubes. After replacement of tubes, it is necessary to recalibrate the bridge in order to obtain the point of optimum regulation and minimum ripple voltage for the power supply. This involves screw-driver adjustment of potentiometers R-137 and R-156 of figure 4-1. The procedure is as follows:

Table IV. Tube Complement*

Reference Symbol	*JAN Type*	*Function*
V-101	5Y3WGTA	Rectifier, power supply
V-102	6080	Series regulating tube
V-103	6AU6WA	Regulating control amplifier
V-104	5651	Voltage reference base
V-105	5651	Voltage stabilizer

* See paragraph 5-12.

a. Replace bolometer mount and bolometer element with a 200-ohm precision resistor in series with a dc milliammeter (0-50 ma. range preferably).

b. Connect power plug of bridge to ac source and turn power switch "ON". Allow 20-minute warm-up period.

c. Set selector switch to "SET ZERO" position. Balance galvanometer, M-102, with "SET ZERO" control, R-148.

d. Adjust R-137 until the milliammeter reads 35 milliamperes.

e. Connect an oscilloscope or ac voltmeter (0-25 milliamperes range preferably) across points A and B of figure 4-1 to read output ripple voltage.

f. Adjust R-156 for minimum reading on oscilloscope or ac voltmeter.

g. Tighten shaft-locks on R-137 and R-156.

5-13. BOLOMETER ELEMENT. To replace the bolometer element, refer to figure 1-3 and proceed as follows:

a. Remove the three clamping screws, H-155, holding the two halves of the bolometer mount together.

b. Remove the mounting screw, H-151, and washer, H-152, holding the bolometer element, RT-106, to the center conductor of Z-106.

c. Carefully lift an edge of the bolometer element and remove it from the mount.

d. Before inserting the new element in the mount, clean the mating surfaces of the mount to remove dust and fragments of the old bolometer element.

e. Slip the new bolometer element over the index pins of Z-106.

f. Replace the mounting screw, H-151, and washer, H-152.

g. Reassemble the two parts of the mount and replace the three clamping screws, H-155, and O-ring washers, H-154. Tighten the screws consecutively a little at a time until very tight.

h. Measure the resistance between the terminals of the dc connector of the mount. This should be approximately 220 ohms.

5-14. INSPECTION.

5-15. SUMMATION BRIDGE TS-730/URM. Only a visual mechanical inspection to determine ease of operation of controls, sticking of meter movements, evidences of corrosion due to humidity or fungus, etc., is necessary if the bridge meets the minimum performance standards of paragraph 5-3. This inspection should be performed after each major repair, after long periods of storage and disuse, and after approximately each 100 hours of operation. Judgment as to the critical nature of defects found during inspection will determine whether repair or replacement of components is necessary.

5-16. R-F ACCESSORIES. If the minimum performance standards of paragraphs 5-2, 5-4 and 5-5 are met, the r-f accessories require a visual mechanical inspection only after long periods of disuse and after each 100 hours of operation. The inspection chart of Table V will indicate the defects to inspect for and the remedial action necessary.

5-17. LUBRICATION.

5-18. No lubrication or preservative is required for any part of this equipment.

Table V. Inspection Chart — R-F Accessories*

Component	*Inspection*	*Remedial Action*
Bolometer Mount	1. Tightness of clamping screws. 2. Signs of corrosion at connectors.	1. Tighten screws if loose. 2. If electrical contact is affected, clean connectors with emery and wash with carbon-tetrachloride.
Attenuators	1. Signs of corrosion at connectors. 2. Mechanical security of center conductor. 3. Possible loose chips in housing.	1. Clean as for Bolometer Mount above. 2. If loose, replace attenuator. 3. If performance standards cannot be met, replace attenuator.
Adapter Connector	1. Signs of corrosion at connectors. 2. Mechanical tightness of center conductor.	1. Clean as above. 2. If loose, replace adapter.
R-F Cord	1. Corrosion or loose connection at end UG-21B/U connectors.	1. Repair or replace conductors.

* See paragraph 5-16.

SECTION VI

FIELD AND FASRON MAINTENANCE

6-1. MINIMUM PERFORMANCE STANDARDS.

6-2. The minimum performance standards outlined in paragraphs 5-2 through 5-5, Section V, are also applicable to this section.

6-3. TROUBLE ANALYSIS.

6-4. SUMMATION BRIDGE TS-730/URM. If the operational trouble-shooting procedure of paragraph 5-7 and Table II do not indicate the specific part of the bridge circuit which is defective, refer to figure 7-1 and the detailed circuit test chart of Table VI, which lists a systematic procedure for locating trouble in the bridge circuit.

6-5. TUBE SOCKET VOLTAGE AND RESISTANCE CHART. A tabulation of tube socket voltages and resistances is given in Table VII. Voltages are measured with a vacuum tube voltmeter or 20,000 ohm-per-volt voltmeter. All readings are from the socket pin listed to chassis ground. All voltages are in volts, dc unless otherwise indicated, and all resistors are in ohms. S-101

Table VI. Circuit Test Chart — Bridge

Procedure	*AN/URM-23 Control Positions*	*Normal Indications*	*Abnormal Indications*	*Possible Causes of Abnormal Indications*
1. Connect 200-ohm precision resistor in series with dc milliammeter in place of bolometer. Connect ac voltmeter at points (1), terminals 1 and 2 of T-101	S-101 "ON". P-101 connected to 115 vac. S-102 at "SET ZERO".	ac voltmeter reads 115 volts ± 10%; dc milliammeter reads 35 ma.	(a) No ac voltage (b) dc current not 35 ma.	(a) Check F-101, F-102, S-101, T-101, I-101, P-101 (b) Readjust R-137.
2. Connect ac voltmeter at points Ⓐ, terminals 3 and 5 of T-101	S-101 "ON". P-101 connected to 115 vac. S-102 at "CALIBRATION LEVEL".	600 volts ac ±10%	(a) No voltage (b) More than 10% variation from 600 volts	(a) Check T-101, V-101, C-101 (b) Replace T-101
3. Connect ac voltmeter at points Ⓑ, terminals 6 and 8 of T-101	S-101 "ON". P-101 connected to 115 vac. S-102 at "CALIBRATION LEVEL".	6.3 volts ac ±10%	(a) No voltage (b) More than 10% variation from 6.3 volts	(a) Check T-101, V-102, V-103 (b) Replace T-101
4. Connect ac voltmeter at points Ⓒ, terminals 9 and 10 of T-101	S-101 "ON". P-101 connected to 115 vac. S-102 at "CALIBRATION LEVEL".	5 volts ac ±10%	(a) No voltage (b) More than 10% variation from 5 volts	(a) Check T-101, V-101 (b) Replace T-101
5. Connect Vacuum Tube Voltmeter at points Ⓓ, pins 5 and 7 of V-104	S-101 "ON". P-101 connected to 115 vac. S-102 at "CALIBRATION LEVEL".	80-90 volts dc	(a) No voltage (b) Voltage outside normal range	(a) Check C-101, C-102, R-149, R-150, R-151, R-154, V-102, V-104 (b) Replace V-104
6. Connect VTVM at points Ⓔ, pin 2 of V-105 and pin 7 of V-104	S-101 "ON". P-101 connected to 115 vac. S-102 at "CALIBRATION LEVEL".	1-2 volts negative with respect to the voltage obtained in step 5.	No voltage or voltage outside limits	Check C-103, C-104, R-152, R-153, R-156, R-157, V-103, V-105
7. Connect VTVM at points (2), A and B of figure 7-1	S-101 "ON". P-101 connected to 115 vac. S-102 at "CALIBRATION LEVEL".	18-22 volts dc	(a) No voltage (b) Voltage outside limits	(a) R-155 open, C-104 shorted (b) R-155 outside of resistance tolerance
8. Connect VTVM at points (3), the negative terminal of M-101 and contact 1B of S-102	S-101 "ON". P-101 connected to 115 vac. S-102 at "CALIBRATION LEVEL".	14 volts dc	No voltage or wrong value of voltage	Readjust R-137. Check R-102, R-109, R-114 through R-136, R-138, R-139, R-140, R-142, R-143, R-147, S-102, S-103, M-101
9. Connect VTVM at points (3), the negative terminal of M-101 and contact 1B of S-102	S-101 "ON". P-101 connected to 115 vac. S-102 at "ADJUST CALIBRATION".	14 volts dc	No voltage or wrong value of voltage	Check R-101, R-105, R-108, R-110, R-113, S-102
10. Connect VTVM at points (4), the negative terminal of M-101 and the center contact of R-148	S-101 "ON". P-101 connected to 115 vac. S-102 at "SET ZERO" Bolometer connected to bridge.	14 volts dc	No voltage or wrong value of voltage	Check R-144, R-145, R-146, R-148, M-102, S-102, P-102, bolometer
11. Connect VTVM at points (4), the negative terminal of M-101 and the center contact of R-148	S-101 "ON". P-101 connected to 115 vac. S-102 at "ADJUST BALANCE". Bolometer connected to bridge. No r-f power. "ADJUST BALANCE" control in extreme counterclockwise position.	14 volts dc	No voltage or wrong value of voltage	Check R-103, R-104-107-112, R-106, R-111

is "ON", P-101 is connected to 115 vac, S-102 is at "CALIBRATION LEVEL", and S-103 at zero.

6-6. RECALIBRATION. Replacement or repair of any component of the power supply section of the bridge requires that the bridge be recalibrated as described in paragraph 5-12.

6-7. R-F ACCESSORIES. The tests covered in paragraphs 5-8 and 5-9 include all field maintenance tests possible.

6-8. INSPECTION SCHEDULE.

6-9. The inspection schedules and procedures of paragraphs 5-15 and 5-16 are applicable to this section.

6-10. OVERHAUL SCHEDULE.

6-11. Under normal operating conditions, the Summation Bridge requires no overhaul so long as the minimum performance standards continue to be achieved. Under extreme climatic conditions such as excessive humidity, extremes of temperature, dust, etc., a mechanical inspection should be performed after each 100 hours of operation and, upon visible evidence of deterioration, judgment should be exercised as to the necessity of overhaul. Complete overhaul information is found in AN 16-30URM23-3, the Handbook of Overhaul Instructions for this equipment.

Table VII. Normal Socket Voltages and Resistances*

Tube.	*Characteristic*	*Pin 1*	*Pin 2*	*Pin 3*	*Pin 4*	*Pin 5*	*Pin 6*	*Pin 7*	*Pin 8*
V-101	Voltage	n.a.	330	n.a.	300 ac	n.a.	300 ac	n.a.	330
	Resistance	n.a.	inf.	n.a.	42	n.a.	42	n.a.	inf.
V-102	Voltage	n.a.	n.a.	n.a.	121	275	162	3.15 ac	3.15 ac
	Resistance	n.a.	n.a.	n.a.	1.47 meg.	470000	2000 to 2500	40	40
V-103	Voltage	81	82	3.15 ac	3.15 ac	121	150	82	n.a.
	Resistance	39000 to 74000	70000	40	40	1.47 meg.	138000	70000	n.a.
V-104	Voltage	n.a.	-3	n.a.	n.a.	82	n.a.	-3	n.a.
	Resistance	n.a.	40	n.a.	n.a.	70000	n.a.	40	n.a.
V-105	Voltage	n.a.	81	n.a.	n.a.	162	n.a.	n.a.	n.a.
	Resistance	n.a.	39000 to 74000	n.a.	n.a.	2000 to 2500	n.a.	n.a.	n.a.

* See paragraph 6-5.

SECTION VII

DIAGRAMS

7-1. SCHEMATIC TEST DIAGRAM. The schematic diagram for the Summation Bridge, with test points indicated, is given in figure 7-1.

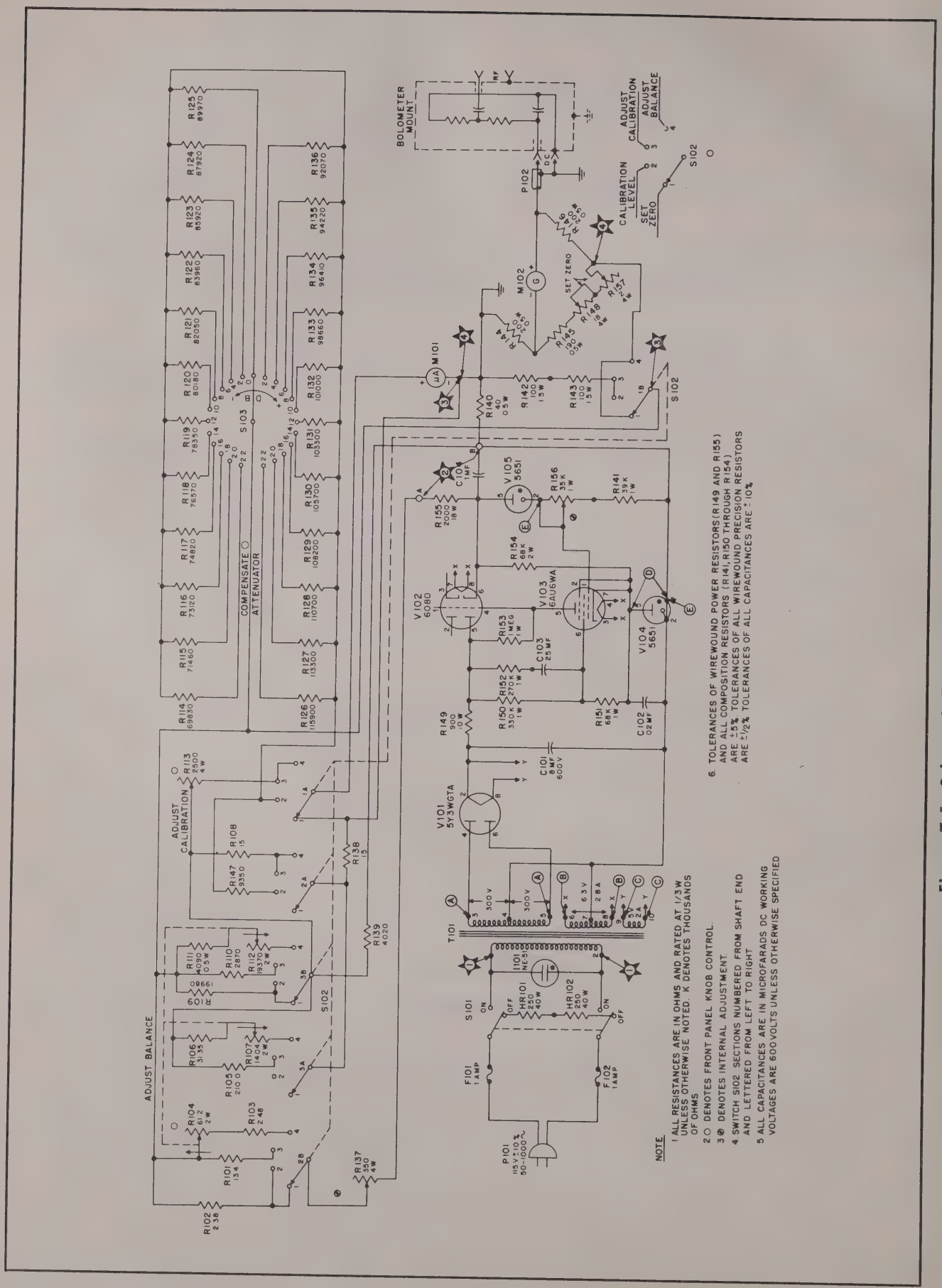


Figure 7-1. Schematic Test Diagram, Summation Bridge

PART THREE

OVERHAUL INSTRUCTIONS

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SECTION I

DESCRIPTION AND LEADING PARTICULARS

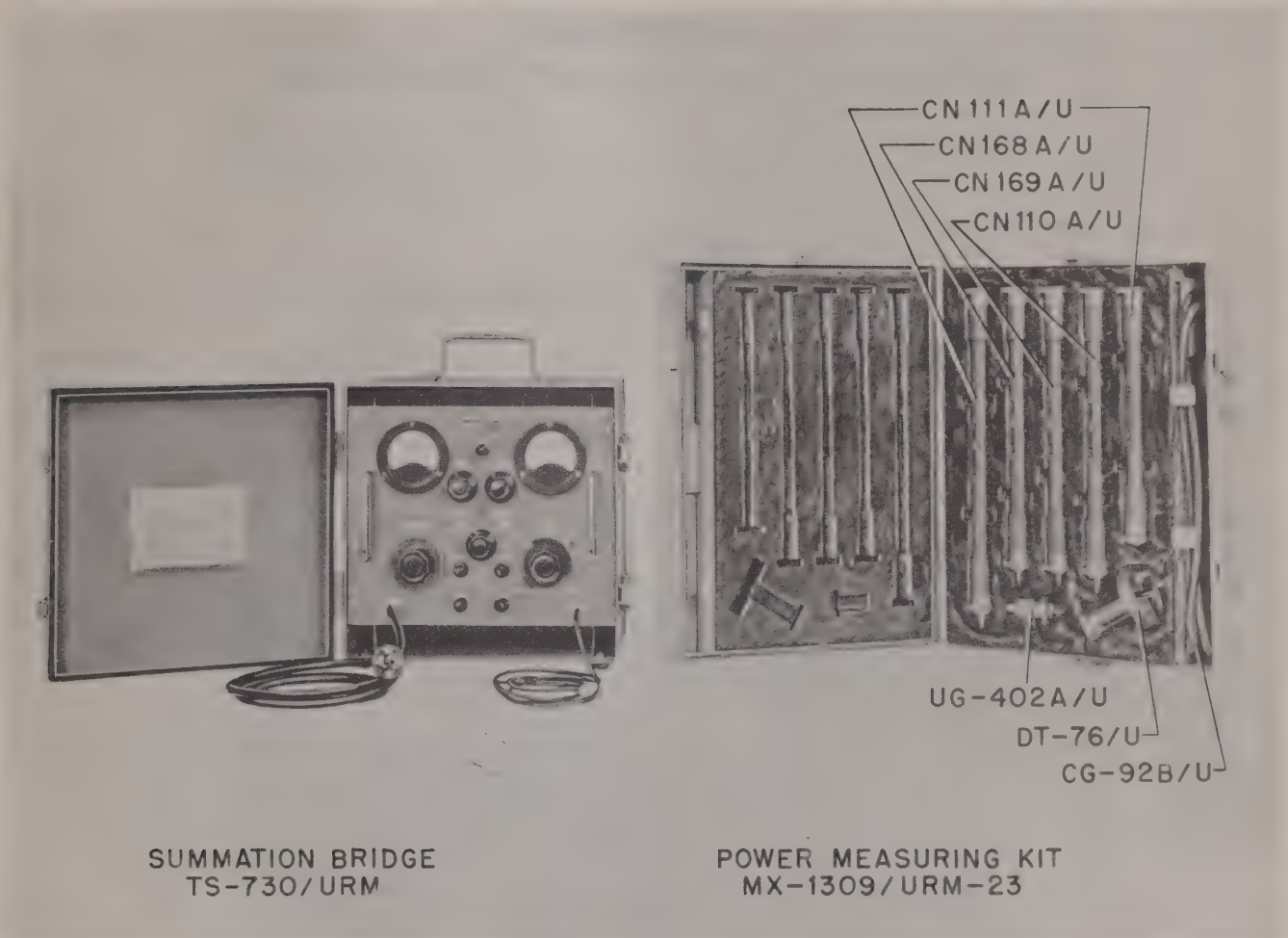

Figure 1-1. Summation Bridge AN/URM-23

1-1. IDENTIFICATION. This publication contains overhaul instructions for Summation Bridge AN/URM-23 (see figure 1-1), manufactured by Bruno-New York Industries Corporation.

1-2. DESCRIPTION. Summation Bridge AN/URM-23 is an item of test equipment designed to measure r-f power from 5 milliwatts to 5 watts in the frequency range between 1000 and 4000 megacycles per second. The equipment consists of two sections, (1) Summation Bridge TS-730/URM and (2) Power Measuring Kit MX-1309/URM-23, each in its own aluminum case. Power Measuring Kit MX-1309/URM-23 contains (1) R-F Attenuators CN-168A/U, CN-169A/U, CN-110A/U and CN-111A/U (3, 6, 10 and 20 db respectively), (2) R-F Bolometer Mount DT-76/U and element, (3) Adapter Connector UG-402/U, (4) R-F Cord CG-92B/U and (5) five spare bolometer elements. All components are designed to operate continuously at ambient temperatures between —40°C and +55°C. Normally, no overhaul is necessary unless the electrical performance has deteriorated due to corrosion, extremes of temperature, excessive dust conditions, etc.

SECTION II
SPECIAL OVERHAUL TOOLS AND TEST EQUIPMENT

2-1. No special tools or test equipment are required to overhaul the Summation Bridge.

SECTION III
SPECIALIZED MAINTENANCE AND REPAIR

3-1. No specialized maintenance is necessary beyond the procedures discussed in AN 16-30URM23-2, the Handbook of Service Instructions for the equipment.

SECTION IV
DISMANTLING AND DISASSEMBLY

4-1. SUMMATION BRIDGE TS-730/URM. To remove the complete panel assembly from its case, unfasten the two outside rows of screws on the panel and slide the panel forward out of the case, as shown in figure 4-1. All bridge components are panel-mounted and easily accessible when the side plates and perforated top and bottom plates are removed. A schematic diagram of the bridge is furnished on the right side plate.

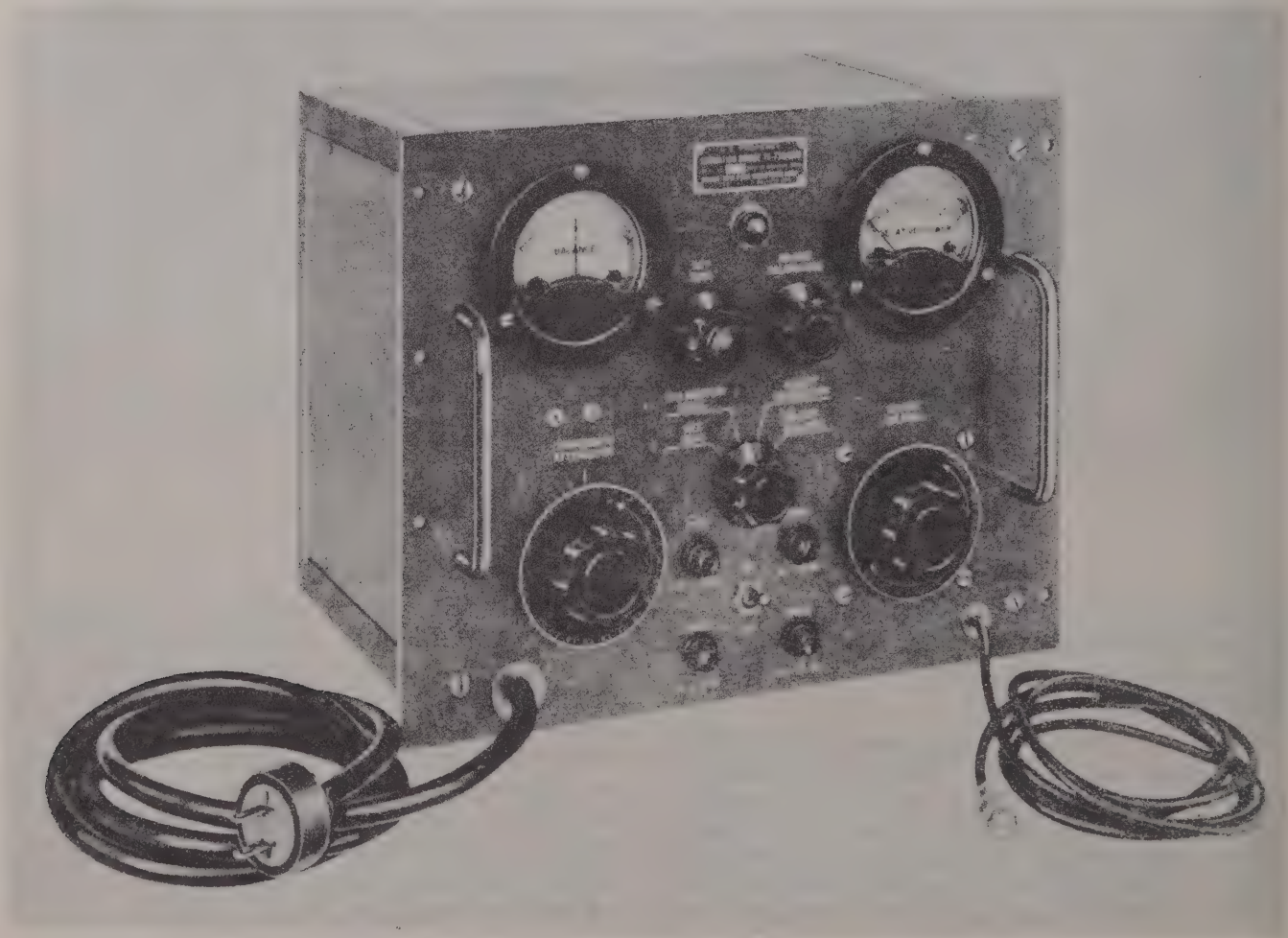

Figure 4-1. Panel Assembly, Summation Bridge TS-730/URM

4-2. POWER SUPPLY. The power supply section of the bridge is constructed as a complete subassembly mounted upon the two angle brackets fastened to the main angle frame (see figures 4-2 and 4-3). This subassembly includes a formed aluminum chassis containing the tubes and condensers C-101 and C-103, a detachable terminal board, power transformer T-101 and filter condenser C-101. These components are bolted together and may be disassembled individually or, if necessary, the complete power supply may be disconnected and detached by (1) unsoldering the four wires (two input and two output) connecting from the power supply to the panel, (2) removing the plate which supports the rear of the triple-ganged potentiometer, (3) unbolting the mounting angles from the side frames and (4) unfastening the four screws holding the resistor plate to the power supply chassis.

4-3. RESISTORS AND CAPACITORS. In general, the resistors and capacitors require no overhaul. All capacitors are mounted on the power supply and, if necessary, may be removed by unsoldering the wires leading to them and removing the appropriate mounting screws. All composition resistors are mounted on the power supply terminal board, while the precision wire-wound resistors are on either the round plate attached to S-103, the "COMPENSATE ATTENUATOR" control, or the plate bolted to the power supply chassis. To detach the round plate, remove the "COMPENSATE ATTENUATOR" dial with the Allen key wrench located on the rear mounting plate. Unfasten the three screws under the dial and pull out switch and plate assembly, after unsoldering the wires from the assembly to the panel cable. To remove the resistor plate fastened to the chassis, unfasten the four mounting screws and lift out.

4-4. TRIPLE-GANGED POTENTIOMETER. The triple-ganged potentiometer, R-104, R-107, R-112, is set at the factory so that the sections track accurately. This tracking adjustment requires specialized equipment and techniques, and in general necessitates replacement of the entire potentiometer unit if the tracking is inaccurate. No overhaul is normally required for the potentiometer so long as the electrical performance of the bridge remains satisfactory. During disassembly and reassembly of the bridge, care must be taken not to place mechanical stress upon the potentiometer contacts or wipers. If the "ADJUST BALANCE" knob is re-

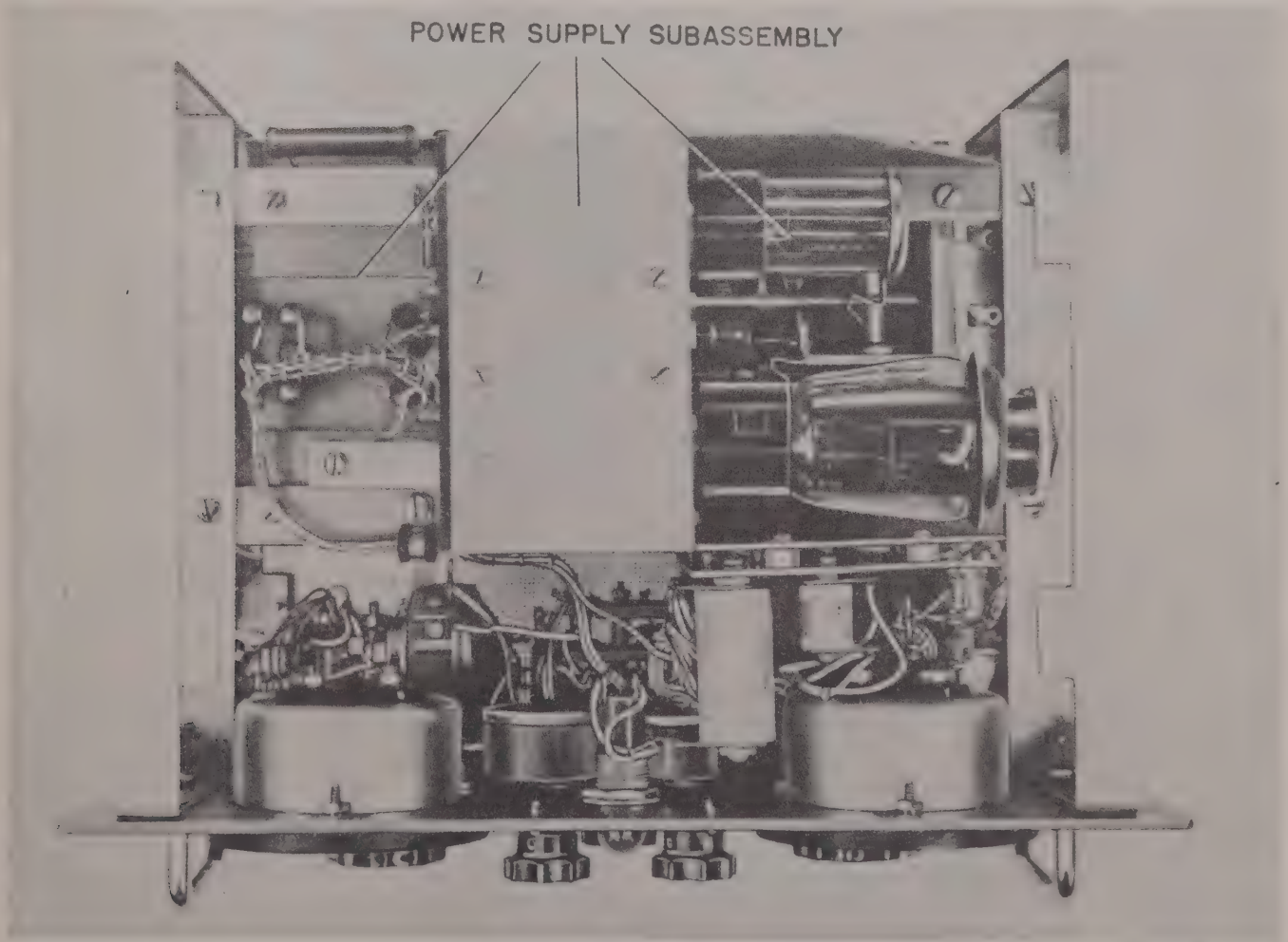

Figure 4-2. Panel Assembly—Top View

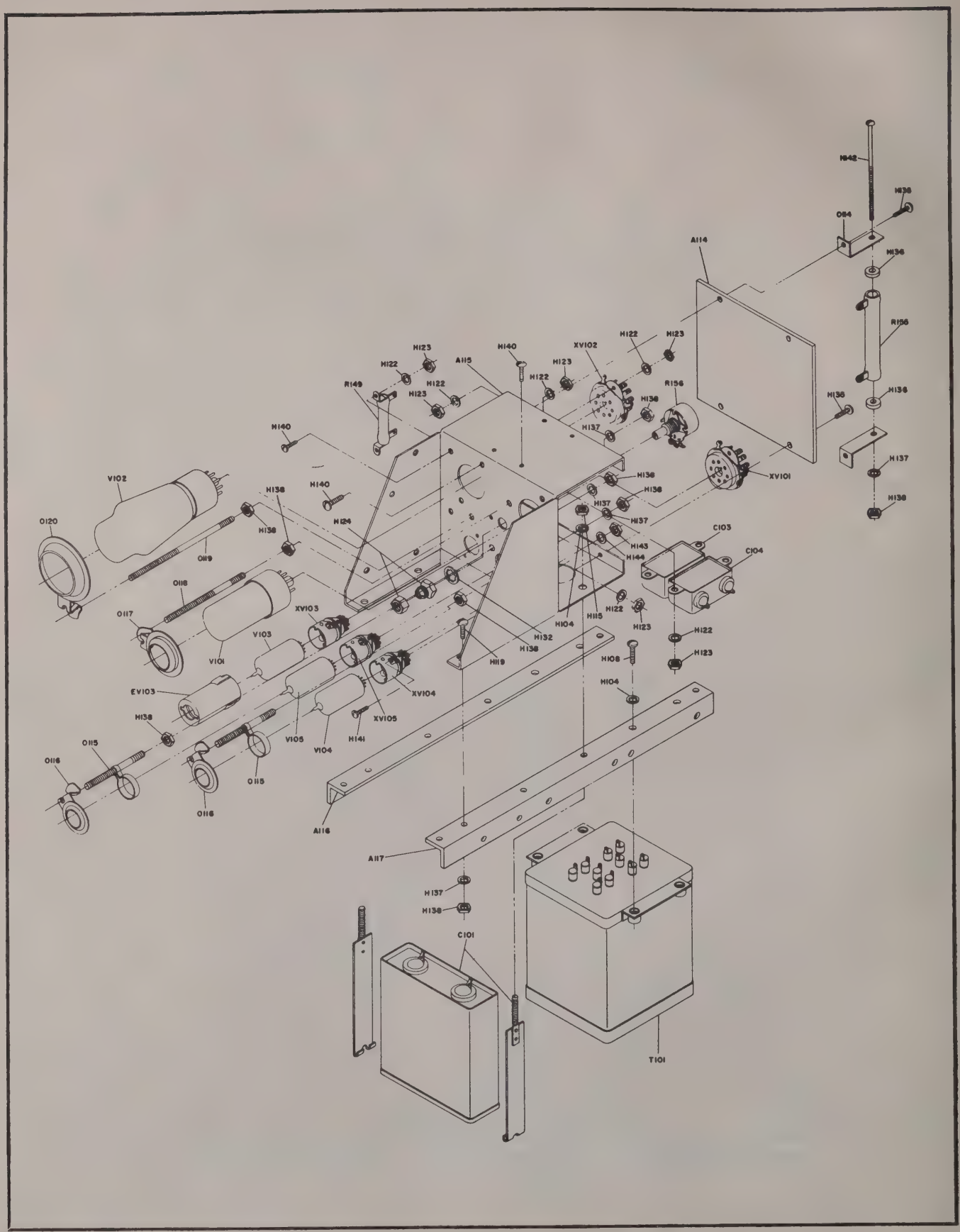

Figure 4-3. Power Supply—Exploded View

moved and replaced, the mechanical stop must be reset as follows:

a. Turn the shaft of the potentiometer to the extreme clockwise position.

b. Back off slightly in a counterclockwise direction until the wiper arm of the potentiometer is seen to just make contact with the end of the contact bar.

c. Replace knob so that the stop on the back of the knob is resting against the stop screw projecting from the panel. Tighten knob set screw.

d. Rotate knob to extreme counterclockwise position and check to make sure that stop again hits stop screw when the potentiometer is almost at the end of its travel.

4-5. PANEL ASSEMBLY. All parts of the bridge not specifically discussed in paragraphs 4-2 through 4-4 are mounted directly on the front panel. The method of disassembly for each is obvious.

4-6. ATTENUATORS AND ADAPTER. No disassembly is possible for the r-f attenuators or adapter connector, since these require factory techniques of silver-soldering and press fits for assembly.

4-7. BOLOMETER MOUNT AND ELEMENT. The disassembly possible for the r-f bolometer mount is limited to the normal separation of the mount required for the replacement of bolometer elements. This procedure is covered in Section IV of AN 16-30URM23-1, the Handbook of Operating Instructions for this equipment. No disassembly may be performed upon the bolometer element.

SECTION V
CLEANING

5-1. SUMMATION BRIDGE TS-730/URM. Since the method of ventilation in the bridge provides a continuous flow of air up through the bottom perforated plate to the top, after long periods of operation, or in dusty climates, appreciable dust may be found within the unit. This will not generally affect the performance of the equipment, but during overhaul periods the entire panel assembly and case interior should be blown out with low-pressure compressed air (approximately 10 lb. per sq. in.). If compressed air is not available, brushing with a soft brush is satisfactory if care is taken not to mechanically damage any parts.

5-2. SWITCHES. The terminals of rotary switches S-102 and S-103 may be cleaned, if necessary, with carbon tetrachloride conforming to Federal Specification O-C-141, or an equivalent solvent.

5-3. TUBE SOCKETS. If extremely dirty, the tube socket receptacles may be cleaned by the application of a small amount of carbon tetrachloride as in paragraph 5-2.

5-4. R-F COMPONENTS. To remove dirt from the connectors of the adapter or attenuators, or from the mating faces of the bolometer mount, carbon tetrachloride may be used. If any of these silver plated surfaces appear to have an excessive oxide tarnish, the equivalent of commercial silver polishing compounds may be used. Care should be taken in the handling of the bullet ends of the connectors not to deform them or change the spring tension of the fingers.

5-5. PRESERVATION. No part of this equipment requires preservation compound of any kind.

SECTION VI
INSPECTION

6-1. SUMMATION BRIDGE TS-730/URM. The inspection for the bridge consists of a visual mechanical inspection and tests to determine tolerances on electronic parts. The visual inspection is for the purpose of determining evidences of frayed wires, wear or corrosion, especially at moving contact points such as switch or potentiometer terminals. Frayed wires should be replaced, while evidence of wear or corrosion requires judgment to decide whether cleaning and overhaul or replacement is warranted. For a guide in the tests to determine whether electronic components are still within their prescribed tolerances, refer to Table I and the schematic diagram on the bridge side panel which lists the nominal values of components. All parts which do not fall within the tolerances listed should be replaced.

6-2. R-F COMPONENTS. The inspection covering the r-f attenuators, adapter and bolometer mount consists of the visual, mechanical and electrical tests discussed in Section V of AN 16-30URM23-2, the Handbook of Service Instructions. If defects are noted and the cleaning procedures of paragraph 5-4 is not effective, the component must be replaced.

Table I. Electrical Test Inspection Chart

Part	*Test Equipment Required*	*Test*	*Acceptable Limits*
Precision Wire-wound Resistors (R-101 through R-103, R-105, R-106, R-108 through R-111, R-114 through R-136, R-138 through R-140, R-142 through R-147)	Wheatstone Bridge (accuracy better than ¼%)	Resistance measurement	± 0.5% of rated value
Power and Heater Resistors (R-149, R-155, HR-101, HR-102)	Ohmmeter	Resistance measurement	± 10% of rated value
Composition Resistors (R-141, R-150 through R-154)	Ohmmeter	Resistance measurement	± 10% of rated value
All Capacitors (C-101 through C-104)	Ohmmeter	Resistance measurement	Open-circuit reading
Single Potentiometers (R-113, R-137, R-148)	Ohmmeter	Resistance between end contacts, and between wiper and each end	± 10% of rated value for total resistance of each potentiometer; smoothly varying between wiper and each end
Three-gang Potentiometer (R-104, R-107, R-112)	Ohmmeter	Total resistance of each section, and resistance between wiper and end of each section	± 10% of rated value for total resistance of each section; smoothly varying between wiper and each end; no mechanical wear on wire or contact arms
All Tubes (V-101 through V-105)	Tube Tester	Standard tube test	Limits prescribed by tester
Transformer T-101	Power Source, 115 volts ac, 50-1000 cycles per second, approx. 0.6 ampere primary current	Application of voltage to primary side	Voltage output: (a) Terminals 3-4 (for 70 ma. load): 300 volts ± 10% (b) Terminals 4-5 (for 70 ma. load): 300 volts ± 10% (c) Terminals 6-7 (for 2.8 amp. load): 3.15 volts ± 10% (d) Terminals 7-8 (for 2.8 amp. load): 3.15 volts ± 10% (e) Terminals 9-10 (for 2.0 amp. load): 5 volts ± 10%
Meter, microammeter M-101	Battery, tapped at 0.0136 volts dc., dc Millivoltmeter, 0-15 mv, (accuracy ±½%)	Parallel M-101 with standard dc Millivoltmeter across 0.0136 volts dc	M-101 should read within ± 2% of standard millivoltmeter
Meter, galvanometer M102	Battery supply, 0-50 microampere dc standard meter (accuracy within ± ½%)	Place M-101 in series with standard meter, battery and load. Adjust load until standard meter reads 22 microamperes	Pointer should deflect to the top of letter "L" in word "BALANCE" on face of meter, or farther. With current reversed, pointer should deflect to the top right edge of letter "N", or farther.

SECTION VII

REPAIR AND REPLACEMENT

7-1. Replace electrical or electronic parts if defective. Replace or repair structural parts as judgment and necessity dictate. Procedures are obvious.

7-2. All precision wirewound resistors must be replaced by exact equivalents both in nominal resistance and tolerance, and should not be replaced by composition resistors even of carefully selected value since the resistance of the latter is subject to drift with time and temperature. The power resistors and composition resistors of the power supply may be replaced by resistors of equal or closer tolerance and of equal or greater power rating. Capacitors may not be replaced with others of lower voltage ratings. The filter capacitor C-101 may be replaced by capacitors equal or larger than 8 microfarads. Electrolytic capacitors are not acceptable in any part of the power supply.

SECTION VIII

REASSEMBLY AND TESTING OF SUBASSEMBLIES AND ASSEMBLIES

8-1. For parts whose disassembly is discussed in detail in Section IV, the reassembly procedure is the reverse of disassembly. The procedure is obvious for all other parts. Follow the schematic wiring diagram of figure 8-1 for all electrical connections. The testing of individual parts is covered in Section VI and for the complete assemblies in AN 16-30URM23-2, the Handbook of Service Instructions.

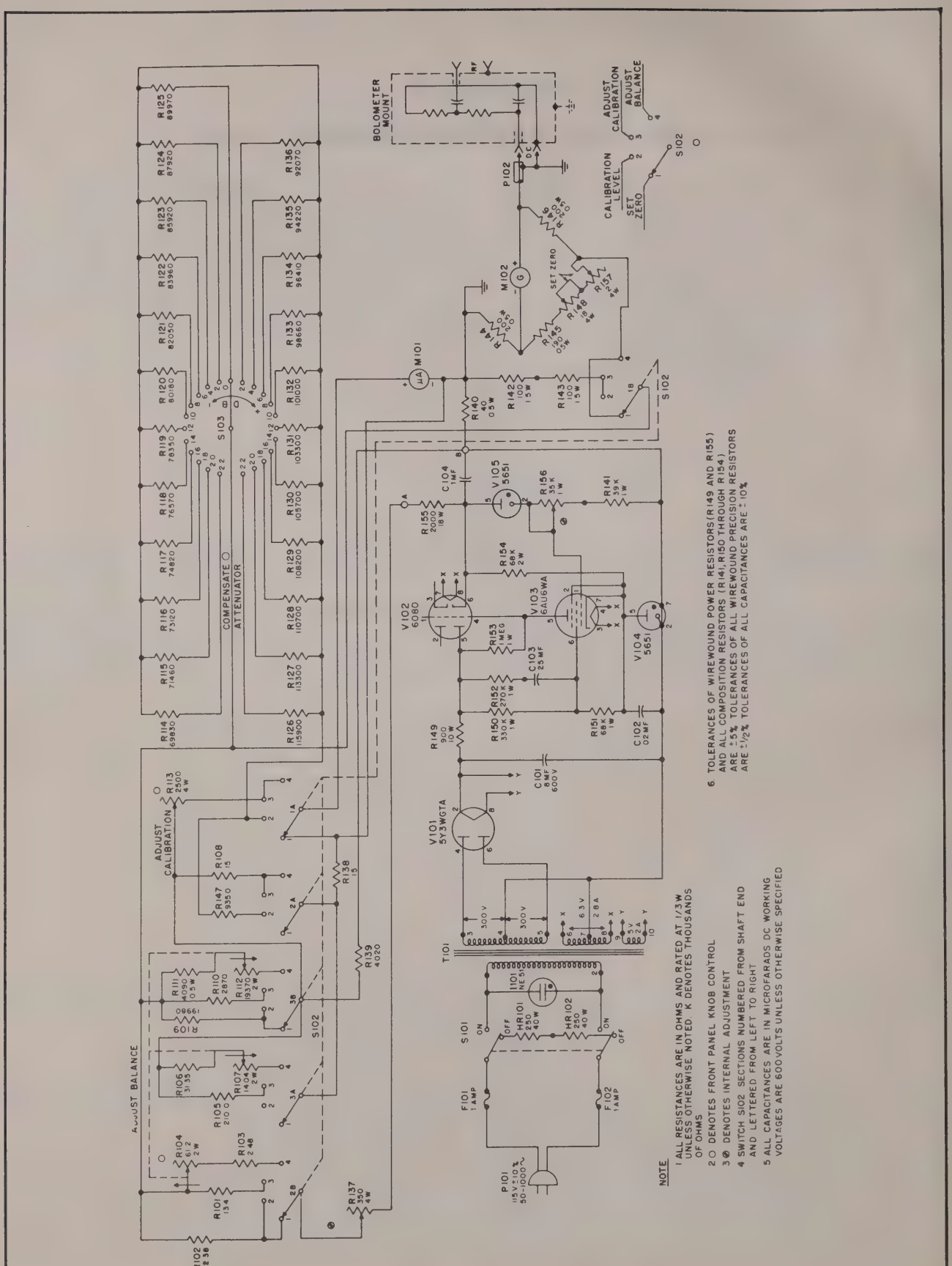

Figure 8-1. Schematic Diagram, Summation Bridge

SECTION IX
REASSEMBLY AND TESTING OF COMPONENTS

9-1. Since the equipment is considered as a single unit, this section is not applicable.

SECTION X
FINAL REASSEMBLY

10-1. See paragraph 11-1.

SECTION XI
INSPECTION AND TESTING

11-1. After reassembly, test the Summation Bridge per paragraph 5-7 of AN 16-30URM23-2, the Handbook of Service Instructions. If any malfunction is indicated, follow the trouble-shooting procedures of Section V and VI of the Service Instructions Handbook. For an indication of the accuracy of r-f power measurements, comparison of measurements with another Bridge in good operating order provides the fastest overall performance test. When the equipment passes all tests satisfactorily it is ready for use, and the Summation Bridge TS-730/URM and the Power Measuring Kit MX-1309/URM-23 accessories may be stored in their respective cases, as illustrated in figure 1-1.

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